

# Teacher Turnover and Access to Effective Teachers in the School District of Philadelphia

Appendix A. Methods

Appendix B. Supporting analysis

See <https://go.usa.gov/xG4Ab> for the full report.

## Appendix A. Methods

This appendix describes the data and methodology used in the study.

### Data

The School District of Philadelphia (SDP) provided data on teacher employment, teacher characteristics, student–teacher linkages, and school characteristics. The SDP Office of Talent Information Management provided data on teacher employment as of September 1, October 31, and April 1 of each school year; teacher characteristics by school year; teachers who left the district by school year; and scores on the teacher evaluation system by school year. The district’s Office of Research and Evaluation provided data on the grades and subjects that teachers taught by school year and data that enabled the study team to identify each student’s teachers by subject for research question 1. Finally, the Office of Research and Evaluation provided data on school characteristics, including student demographic characteristics, student proficiency level on state math and English language arts assessments, and school-level results from districtwide teacher surveys. A list of all data sources and variables used in the study, along with the years of data provided and used and the research questions informed by each set of variables, is in table A1.

The study team created additional variables using data that SDP provided. These included teachers’ pension and retirement eligibility, teachers’ commute time from home to school for each school year, and the number of years a principal led a school by school year. Constructs were also created using scores on the teacher survey to describe teachers’ perceptions of school leadership, climate, student behavior, and the level of teacher autonomy, respect, and collaboration at the school. Additional details on how the study team created these variables appear after table A1.

The study team also used data on school-level student–teacher ratios from the U.S. Department of Education’s Common Core of Data (U.S. Department of Education, 2017). These data were used in the analysis of research questions 3a and 3b. Data on each teacher’s class size were not available. The school-level student–teacher ratio denotes the number of students per teacher in a school.

The years of data available differed by variable. To create consistency across the analyses, data from 2010/11 through 2016/17 were used for analyses that included teacher characteristics other than teacher effectiveness, and data from 2014/15 through 2016/17 were used for analyses that included teacher evaluation ratings and effectiveness scores or school characteristics. For the timespan 2014/15 through 2016/17 the study team had both teachers’ Pennsylvania Value-Added Assessment System (PVAAS) scores and effectiveness scores from the

teacher evaluation system, as well as data on all school characteristics, including the percentage of economically disadvantaged students and teacher survey responses.

**Table A1. Data variables and sources for data provided by the School District of Philadelphia, 2010/11–2017/18**

Source	Years of data provided	Years of data included in analysis	Variables used in analysis	Research questions
School District of Philadelphia Office of Talent Information Management, current active teachers (September 1, October 31, and April 1 time points)	2010/11–2017/18	2010/11–2016/17	<ul style="list-style-type: none"> <li>• Teacher ID</li> <li>• School ID</li> <li>• Employment time point</li> </ul>	2, 3, 3a, and 3b
School District of Philadelphia Office of Talent Information Management, current active teachers as of October 31	2010/11–2017/18	2010/11–2016/17	<ul style="list-style-type: none"> <li>• Teacher ID</li> <li>• School ID</li> <li>• School year</li> <li>• Job title</li> <li>• Gender</li> <li>• Race/ethnicity</li> <li>• Hire date</li> <li>• Years since hire date</li> <li>• Home address</li> <li>• Attendance rate</li> </ul>	All questions
School District of Philadelphia Office of Talent Information Management, teachers who resigned, retired, or were terminated	2010/11–2017/18	2010/11–2016/17	<ul style="list-style-type: none"> <li>• Teacher ID</li> <li>• School year</li> <li>• Date left the district</li> </ul>	2, 3, 3a, and 3b
School District of Philadelphia Office of Research and Evaluation, data on courses and grade levels taught	2010/11–2017/18	2010/11–2016/17	<ul style="list-style-type: none"> <li>• Teacher ID</li> <li>• School year</li> <li>• Course name</li> <li>• Course grade level taught</li> <li>• Course subject area taught</li> </ul>	All questions
School District of Philadelphia Office of Talent Information Management, data on end-of-year teacher effectiveness	2013/14–2016/17	2014/15–2016/17	<ul style="list-style-type: none"> <li>• Teacher ID</li> <li>• School year</li> <li>• PVAAS score (0–3)</li> <li>• Teacher effectiveness score (0–3)</li> <li>• Teacher evaluation rating (failing, needs improvement, proficient, distinguished)</li> </ul>	All questions
School District of Philadelphia, Office of Research and Evaluation, student–teacher course linkages, grades 3–8	2010/11–2017/18	2014/15–2016/17	<ul style="list-style-type: none"> <li>• Teacher ID</li> <li>• Student ID</li> <li>• School ID</li> <li>• School year</li> <li>• Course grade level</li> <li>• Course subject area</li> <li>• Student race/ethnicity</li> <li>• Student economically disadvantaged status</li> </ul>	1

Source	Years of data provided	Years of data included in analysis	Variables used in analysis	Research questions
School District of Philadelphia, Office of Research and Evaluation, longitudinal school list	2010/11–2017/18	2010/11–2016/17	<ul style="list-style-type: none"> <li>• School ID</li> <li>• School year</li> <li>• School address</li> <li>• School grade span</li> <li>• Principal name</li> </ul>	All questions
School District of Philadelphia Office of Talent Information Management, principals with start dates at school	2017/18	2017/18	<ul style="list-style-type: none"> <li>• School ID</li> <li>• Employee ID</li> <li>• Date principal started at the school</li> </ul>	2, 3a, and 3b
School District of Philadelphia, Office of Research and Evaluation, data on school enrollment and demographics	2010/11–2017/18	2014/15–2016/17	<ul style="list-style-type: none"> <li>• School ID</li> <li>• School year</li> <li>• Percentage of students by race/ethnicity</li> </ul>	2, 3a, and 3b
	2012/13–2017/18	2014/15–2016/17	<ul style="list-style-type: none"> <li>• Percentage of economically disadvantaged students</li> </ul>	2
School District of Philadelphia, Office of Research and Evaluation, results on the Pennsylvania System of School Assessment and Keystone exams	2010/11–2017/18	2014/15–2016/17	<ul style="list-style-type: none"> <li>• School ID</li> <li>• School year</li> <li>• Percentage of students by student proficiency level in math and English language arts</li> </ul>	2, 3a, and 3b
School District of Philadelphia, Office of Research and Evaluation, teacher responses to district survey	2014/15–2017/18	2014/15–2016/17	<ul style="list-style-type: none"> <li>• School ID</li> <li>• School year</li> <li>• Percentage of teachers responding positively or negatively by survey question</li> </ul>	2, 3a, and 3b

PVAAS is Pennsylvania Value-Added Assessment System.

Source: Authors' summary of data provided by the School District of Philadelphia for 2010/11–2017/18.

### ***Variables created by the study team***

***Pension and retirement eligibility.*** The study team created variables of whether teachers were vested in the Pennsylvania Public School Employees' Retirement System (PSERS) or eligible for retirement by using a combination of teachers' hire date, age, and years employed in the district. Although PSERS eligibility is based on employment in public schools across the state, the study team had data only on teachers' employment in SDP. Therefore, these variables may undercount the number of teachers who were vested or eligible for retirement. The variables were used in the analysis of research questions 3a and 3b because teachers' PSERS eligibility could influence the likelihood that teachers would continue teaching in the district.

***Commute time.*** To estimate a teacher's commute time between home and school, the study team used teachers' home addresses from the Office of Talent Information Management's data file on current active teachers and school addresses from the Office of Research and Evaluation's longitudinal school list. First, the addresses were converted into latitude and longitude coordinates using the Esri ArcGIS geocoder. Then, using the Google Distance Matrix application programming interface, which includes traffic information, the driving time between each home and school address combination for a 7:30 a.m. arrival on a Tuesday was estimated. In some cases the same home and school address combination resulted in different commute times because of differences in the route

taken and variation in estimated traffic conditions. In these cases the study team averaged the estimated commute times. The maximum commute time was limited to two hours (affecting 0.2 percent of observations).

*Years principal led the school.* To calculate the number of years a school principal led a particular school, the study team first used the Office of Talent Information Management's data file of principals in the 2017/18 school year. This file included each school operating in 2017/18, the principal leading the school in 2017/18, and the date the principal began leading the school (which could have been before 2017/18). These data were used to calculate the number of years each principal led a particular school for all schools operating in 2017/18. However, the data file could not be used to calculate the years of principal leadership in all years from 2010/11 through 2016/17. Some schools closed during that period and therefore were not included in the 2017/18 data file. In addition, principals who left a school before 2017/18 were not included in the 2017/18 data file. For example, if a school's principal in 2017/18 began at that school in 2014/15, the study team could calculate the years of principal leadership in 2014/15 (zero years), 2015/16 (one year), and 2016/17 (two years). However, the years of principal leadership at that school before 2014/15 could not be calculated.

To address this limitation, the study team supplemented the data file of principals in the 2017/18 school year by using the principal names from the Office of Research and Evaluation's longitudinal school list to look for changes in principals from 2001/02 through 2016/17. First, the study team created consistency across names by removing titles (for example, Mr., Ms., Dr.), hyphens, and other punctuation or language that would make it difficult to compare names across years. The team then noted when a principal's first name, last name, or both changed from one year to the next. Years in which both the first and the last names changed were considered years in which the principal changed, and therefore the number of years of principal leadership started at zero. Years in which neither the first nor last name changed were considered years in which the principal stayed at the same school, and the years the principal led the school was increased by one. For schools with more than one principal, the principal was considered to be constant if at least one principal remained consistent across years. Schools could have more than one principal if one principal was on leave and another principal was filling in. In addition, the district might assign two or three principals to large schools. The study team reviewed cases in which the first name changed with no change in the last name, or the last name changed with no change in the first name. The majority of these cases were due to nicknames, misspellings, and compound names; therefore, the principal was assumed to be the same unless both the first and last name changed.

*Survey constructs.* Results from the annual district teacher survey administered since 2014/15 were used to create six conceptually distinct constructs that described each teacher's school environment. SDP provided survey results for schools with at least a 25 percent response rate or 25 teachers responding. The average response rate was 64 percent and ranged from 25 percent to 100 percent. Eleven percent of schools in the study did not have survey results; however, it was not possible to determine whether this was because of low response rates at these schools or because the schools were excluded from the survey. The study team aligned the constructs with the topics SDP used to group survey questions (climate, instruction, leadership, professional capacity, and parent/guardian community ties). For each school year, constructs reflect the percentage of teachers in a school who responded positively to questions included in the construct. Construct values ranged from 0 percent to 100 percent and were calculated by dividing the total number of positive responses to each question (responses in the top two positive response categories on a four- or five-point scale) by the total number of responses for that question and then averaging the percentage of positive responses over all questions in the construct. No adjustments were made for nonresponse at the question level, meaning that teachers contributed data only for the questions they answered. Samples of the questions included in each construct are in table A2.

**Table A2. Teacher survey constructs and sample questions, School District of Philadelphia, 2014/15–2016/17**

Survey construct	Sample questions
School climate (43 questions)	<p><i>How often are the following statements true about your classroom? (never, rarely, occasionally, or most or all of the time)</i></p> <ul style="list-style-type: none"><li>- My class is interrupted by announcements or messages from the office or colleagues</li><li>- My students treat each other with respect</li></ul> <p><i>How much do you agree or disagree with the following statements? (strongly disagree, disagree, agree, or strongly agree)</i></p> <ul style="list-style-type: none"><li>- Curriculum, instruction, and learning materials are consistent among teachers in the same grade level at my school</li><li>- Teacher morale is high at my school</li><li>- Teachers at my school have high expectations for students</li></ul> <p><i>To what extent do you consider each of the following factors a challenge to student learning in your school? (a great challenge, a moderate challenge, a slight challenge, not a challenge)</i></p> <ul style="list-style-type: none"><li>- Lack of high-quality professional development opportunities for teachers</li><li>- Lack of school resources to provide extra help to students who need it</li><li>- School crime/safety</li><li>- Lack of support from parents and guardians</li></ul>
School leadership (11 questions)	<p><i>The principal at this school (strongly disagree, disagree, agree, or strongly agree):</i></p> <ul style="list-style-type: none"><li>- Communicates a clear mission for our school</li><li>- Sets high standards for student learning</li><li>- Sets clear expectations for teachers</li><li>- Provides me with constructive feedback based on formal or informal observation(s) of my teaching</li><li>- Works to create a sense of community in this school</li><li>- Promotes parent, guardian, and community involvement in the school</li></ul>
Teacher autonomy (16 questions)	<p><i>How much control do you have over the following in your class? (none, a little, some, a great deal)</i></p> <ul style="list-style-type: none"><li>- Determining course objectives</li><li>- Choosing books and other instructional materials</li><li>- Setting the pace for covering topics</li><li>- Setting standards of behavior in my classroom</li><li>- Choosing the teaching methods and strategies I use with my students</li><li>- Choosing the evaluation and assessment activities I use in my class</li></ul> <p><i>How much do you agree or disagree with the following statements? (strongly disagree, disagree, agree, or strongly agree)</i></p> <ul style="list-style-type: none"><li>- I am encouraged to try new teaching approaches in my classrooms</li><li>- I am encouraged to innovate to improve my teaching</li><li>- I am willing to question others' views on issues of teaching and learning</li><li>- I am expected to continually learn and seek out new ideas</li><li>- I am free to be creative in the teaching methods and strategies I use in the classroom</li></ul>
Teacher respect (8 questions)	<p><i>To what extent do you feel respected by (not at all respected, a little respected, somewhat respected, respected a great deal):</i></p> <ul style="list-style-type: none"><li>- District/charter administrators</li><li>- Your principal</li><li>- Teachers in your school</li><li>- Parents/guardians</li><li>- Students</li></ul>
Student behavior (14 questions)	<p><i>How often are the following statements true about your classroom? (never, rarely, occasionally, most or all of the time)</i></p> <ul style="list-style-type: none"><li>- My students complete their assigned work</li><li>- My students are motivated to learn</li><li>- Students misbehave in my classroom</li><li>- My students ask me questions when they need help</li><li>- My students work hard in my classes</li></ul>

Survey construct	Sample questions
Collaboration (10 questions)	<p><i>How often, if at all, do you collaborate with other teacher(s) or other school staff at your school about the following topics? (never or almost never, 1–4 times a year, 5–7 times a year, monthly or about monthly, weekly or about weekly, daily or almost daily)</i></p> <ul style="list-style-type: none"> <li>- Classroom management strategies/interventions</li> <li>- Identifying, developing, or revising curricular materials</li> <li>- Effective instructional strategies</li> <li>- The individual learning needs of students</li> <li>- Coordination of instruction across grade levels</li> </ul>

Source: Authors' summary of questions from the School District of Philadelphia's teacher survey.

### Sample

The analytic sample was drawn from school personnel included in the Office of Talent Information Management's data file on active teachers for each school year. The sample was limited to personnel with a "teacher" job title, which excluded personnel such as instructional specialists, academic coaches, and school counselors. To limit the sample to teachers working in kindergarten–grade 12, the sample excluded teachers with a preschool teacher title and teachers working in schools that did not serve kindergarten–grade 12. The data provided by the district did not include teachers in charter schools.

*Sample characteristics.* Seventy-four percent of the teachers in the sample identified as female. Sixty-eight percent identified as White, 26 percent as Black, 3 percent as Hispanic, and 3 percent as another race/ethnicity (table A3).

**Table A3. Demographic characteristics of teachers in the School District of Philadelphia, overall and by school year, 2010/11–2016/17 (percent unless otherwise indicated)**

Teacher demographic characteristic	Overall									
	Sample size <sup>a</sup>	Percent	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	
<b>Gender</b>										
Male	59,126	26.2	28.0	25.9	26.0	25.7	25.9	25.9	25.4	
Female	59,126	73.8	72.0	74.1	74.0	74.3	74.1	74.1	74.6	
<b>Race/ethnicity</b>										
Black	59,102	25.5	25.6	26.3	26.2	26.0	25.5	24.8	24.0	
Hispanic	59,102	2.9	2.7	2.7	2.7	3.0	3.1	3.1	3.1	
Other	59,102	3.4	3.4	3.3	3.4	3.5	3.4	3.5	3.7	
White	59,102	68.1	68.2	67.8	67.6	67.5	68.0	68.7	69.2	

a. The number of teacher-years represented in the analysis (teachers multiplied by their years employed in the district from 2010/11 through 2016/17).  
Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

Roughly half of teachers taught math, English language arts, science, or social studies, and this remained consistent across school years (teachers could teach multiple subjects, so percentages do not sum to 100; table A4). A large majority (83 percent) of teachers were general education teachers; the rest (17 percent) were special education teachers. This breakdown also remained consistent across school years. By grade level 57 percent of teachers taught elementary school grades, 33 percent taught middle school grades, and 28 percent taught high school grades. The share of high school teachers declined during the study years, from 32 percent in 2010/11 to around 26 percent in later years. The number of schools at each grade level in the district changed because of a districtwide initiative in 2010/11 during which some schools were converted to charter schools and because of

school closures in 2011/12 and 2012/13, which might have changed the share of teachers at each grade level during the study years.

Most (60 percent) teachers had regular attendance, but a substantial proportion (35 percent) were frequently absent, missing 10 or more days of teaching in a school year. Five percent of teachers missed 45 or more days in a school year; these teachers were included in the analyses as a separate group because it is likely that extenuating circumstances such as family or medical leave contributed to the high rate of absences. The percentage of teachers who were frequently absent increased over time, from 31 percent in 2010/11 to 38 percent in 2016/17 (see table A4). More than a quarter (28 percent) of teachers had a commute of less than 15 minutes, and nearly three-quarters (74 percent) of teachers had a commute of less than 30 minutes.

**Table A4. Professional characteristics of teachers in the School District of Philadelphia, overall and by school year, 2010/11–2016/17 (percent unless otherwise indicated)**

Teacher professional characteristic	Overall									
	Sample size <sup>a</sup>	Percent	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	
<b>Subject taught</b>										
English language arts	49,650	50.7	53.8	52.7	50.6	50.5	50.0	48.8	48.4	
Math	49,650	54.2	58.7	55.8	53.8	54.0	53.2	52.6	51.4	
Science	49,650	47.5	49.4	48.2	48.0	48.0	47.2	46.4	45.1	
Social studies	49,650	51.4	55.4	52.5	51.4	51.3	50.9	49.8	48.4	
<b>General education/special education</b>										
General education	59,126	82.9	82.7	83.3	83.3	82.3	82.6	83.3	82.7	
Special education	59,126	17.1	17.3	16.7	16.7	17.7	17.4	16.7	17.3	
<b>Grade level taught</b>										
Elementary school grades (kindergarten–5)	60,680	56.9	53.8	55.4	56.1	57.7	58.3	59.5	58.4	
Middle school grades (6–8)	60,680	33.2	34.3	34.3	33.5	32.5	32.2	32.3	32.6	
High school grades (9–12)	60,680	28.1	32.1	28.6	28.5	27.1	26.4	26.0	26.8	
<b>Attendance</b>										
Regular (95 percent attendance or greater)	59,104	60.3	64.3	61.7	59.8	59.0	59.9	58.3	57.9	
Frequently absent (75–94 percent attendance)	59,104	34.9	31.2	33.1	35.4	35.7	35.5	37.0	37.9	
Less than 75 percent attendance	59,104	4.8	4.5	5.2	4.8	5.3	4.6	4.7	4.2	
<b>Commute time</b>										
Shorter than 15 minutes	54,659	27.6	27.6	27.9	27.7	27.7	27.2	27.3	27.4	
15–29 minutes	54,659	46.8	47.1	46.8	46.6	46.1	46.4	46.7	47.5	
30–59 minutes	54,659	23.9	23.0	23.7	24.0	24.5	24.7	24.4	23.1	
60 minutes or longer	54,659	1.8	2.2	1.6	1.7	1.7	1.7	1.6	1.9	

Note: Teachers could teach multiple subjects or multiple grade levels; therefore, percentages for subject taught and grade level taught categories do not sum to 100.

a. The number of teacher-years represented in the analysis (teachers multiplied by their years employed in the district from 2010/11 through 2016/17).  
Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

The percentage of teachers with four or fewer years of teaching in the district declined from 37 percent in 2010/11 to 16 percent in 2014/15, then increased again to 26 percent in 2016/17 (table A5). The decline in the percentage of teachers new to the district between 2010/11 and 2014/15 may be due to restructuring and layoffs associated with the conversion of some schools to charter schools, school closures, and the 2012/13 budget shortfall.

**Table A5. Teachers' years of teaching in the School District of Philadelphia, by school year, 2010/11–2016/17 (percent unless otherwise indicated)**

School year	Number of teachers	4 or fewer years	5–10 years	11–17 years	More than 17 years
2010/11	10,178	37.4	22.8	18.2	20.5
2011/12	9,052	29.4	25.7	21.4	21.2
2012/13	8,847	27.8	26.1	22.5	20.8
2013/14	8,251	21.3	29.7	25.2	19.9
2014/15	8,098	16.0	33.2	26.7	20.2
2015/16	8,179	17.6	29.2	28.3	21.2
2016/17	8,207	25.5	23.5	26.9	21.8
All years (average) <sup>a</sup>	8,687	25.5	27.0	23.9	20.8

a. The overall number of teachers across all years is an average of the number of teachers in the sample in each year.

Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

Teachers receive one of four ratings in the educator evaluation system based on their underlying effectiveness score: failing (the lowest rating), needs improvement, proficient, or distinguished (the highest rating). Table A6 shows the percentage of teachers in each evaluation rating category overall and by school year for 2014/15 through 2016/17.

**Table A6. Distribution of teacher evaluation ratings and average scores in the School District of Philadelphia, overall and by school year, 2014/15–2016/17 (percent of teachers unless otherwise indicated)**

Teacher evaluation rating	Overall	2014/15	2015/16	2016/17
<b>PVAAS score<sup>a</sup></b>				
Failing or needs improvement (0–1.49) <sup>b</sup>	14.1	7.8	6.9	47.8
Proficient (1.5–2.49)	56.5	70.8	51.5	34.0
Distinguished (2.5–3)	29.5	21.4	41.6	18.2
Average PVAAS score (all categories)	2.1	2.1	2.3	1.4
<b>Sample size<sup>c</sup></b>	<b>5,308</b>	<b>2,161</b>	<b>2,262</b>	<b>885</b>
<b>Teacher effectiveness score</b>				
Failing or needs improvement (0–1.49) <sup>b</sup>	4.1	4.8	2.9	4.7
Proficient (1.5–2.49)	84.0	89.4	76.9	85.9
Distinguished (2.5–3)	11.9	5.8	20.2	9.3
Average effectiveness score (all categories)	2.1	2.0	2.2	2.0
<b>Sample size<sup>c</sup></b>	<b>22,216</b>	<b>7,462</b>	<b>7,715</b>	<b>7,039</b>

PVAAS is Pennsylvania Value-Added Assessment System.

Note: Percentages may not sum to 100 because of rounding.

a. In school years 2014/15 and 2015/16 teachers were assigned a categorical PVAAS score of 0, 1, 2, or 3. In school year 2016/17 PVAAS scores were calculated as a rolling average of the three previous years' PVAAS scores and therefore were a continuous measure.

b. The bottom two evaluation rating categories (failing and needs improvement) were combined because of small sample sizes in the failing category.

c. The number of teacher-years represented in the analysis (teachers multiplied by their years employed in the district from 2014/15 through 2016/17).

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

Pennsylvania Value-Added Assessment System (PVAAS) scores are one component of SDP's educator evaluation system and provide an estimate of the academic growth of a teacher's students based on students' scores on the state assessment. PVAAS scores are available for teachers in tested grades and subjects (grades 4–8 and math and English language arts) beginning in 2014/15. In 2014/15 and 2015/16 teachers received a PVAAS score of 0, 1, 2, or 3. Beginning in 2016/17 PVAAS scores were calculated as a three-year rolling average based on scores from the previous three consecutive years, so only teachers with three years of PVAAS scores received scores in 2016/17. Because of the changes in how PVAAS scores were calculated and the composition of teachers who received PVAAS scores, analysis results presented in the main report do not include the 2016/17 PVAAS scores.

A teacher's effectiveness score is a summative measure that includes scores based on formal classroom observations, student learning objectives, PVAAS scores, and a school performance profile, which captures a school's overall performance. A teacher's effectiveness score is calculated based on the measures available for a teacher.<sup>1</sup> All teachers receive an effectiveness score. However, beginning in 2016/17 teachers who were new to the district and had not taught for at least three years in another Pennsylvania district and teachers who had received an unsatisfactory rating in the previous year were placed in the peer assistance and review program and did not receive an effectiveness score. These teachers account for 3 percent of the sample and were not included in the analyses of teachers' effectiveness scores.

The distribution of teachers by effectiveness score rating varied from year to year, possibly because the district's evaluation system had begun in 2013/14 and was still in its early years of implementation. Across years, though, a vast majority of teachers received a proficient rating (77–89 percent), and the smallest category was teachers with ratings of failing or needs improvement (3–5 percent; see table A6). Some 6–20 percent of teachers received the highest rating (distinguished) across school years. Average effectiveness scores were fairly consistent across years, ranging from 2.0 to 2.2.

*Analytic samples for research questions 1, 3a, and 3b.* The analysis for research question 1 required data that linked individual students to teachers. Therefore, the sample for this analysis included only teachers with available student–teacher linkages in grades 3–8. The analysis was limited to grades 3–8 because the student–teacher linkages in these grades are likely to be more accurate because the linkages are used to calculate PVAAS scores. In addition, only teachers with effectiveness scores or PVAAS scores could be included in the analysis of differences based on teacher evaluation scores. Only teachers teaching subjects that are part of the Pennsylvania state assessments receive PVAAS scores, which further reduces the sample for the analysis of differences based on PVAAS scores.,

The sample for the effective teaching gap (ETG) analysis for research question 1 also included students. The ETG estimates were based on 262,134 student–teacher observations for economically disadvantaged students and 121,898 observations for non–economically disadvantaged students. Across all schools 73 percent of students identified as economically disadvantaged. The ETG estimates by student race/ethnicity included 56,448 observations for White students, 190,934 observations for Black students, and 81,239 observations for Hispanic students. Schools with 10 or fewer students were excluded from the analysis. In 2017, 55 percent of students identified as Black, 19 percent as Hispanic, and 12 percent as White. In general, schools varied in their socioeconomic and racial/ethnic composition. Though most schools had a majority of students identified as Black or economically disadvantaged, there was sufficient variation within schools and between schools to conduct the ETG analysis (table A7).

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<sup>1</sup> For example, for teachers with all measures available, observation scores account for 50 percent of their effectiveness score, student learning objectives account for 20 percent, PVAAS scores account for 15 percent, and the school performance profile accounts for 15 percent. However, for teachers missing PVAAS scores, observations account for 50 percent, student learning objectives account for 35 percent, and the school performance profile accounts for 15 percent (School District of Philadelphia, 2017).

**Table A7. Selected school-level student demographic characteristics for the School District of Philadelphia, 2014/15–2016/17 (percent of students)**

Percentile	Identified as economically disadvantaged			Identified as Black			Identified as Hispanic			Identified as White		
	2014/ 15	2015/ 16	2016/ 17	2014/ 15	2015/ 16	2016/ 17	2014/ 15	2015/ 16	2016/ 17	2014/ 15	2015/ 16	2016/ 17
Minimum	20.7	20.4	20.9	1.8	1.8	1.5	0.0	0.0	0.0	0.0	0.0	0.0
25th percentile	60.6	64.5	68.2	28.4	24.2	25.0	2.6	2.4	3.1	1.0	1.1	1.0
Median	70.2	72.3	76.7	56.6	59.1	55.8	9.5	7.5	7.8	2.7	2.2	2.9
75th percentile	78.6	80.1	84.0	90.5	89.7	87.7	26.8	27.1	26.3	16.7	14.3	12.5
Maximum	90.0	89.0	93.2	97.8	97.8	97.9	85.6	86.8	89.0	86.9	86.5	84.7
Overall average	67.1	69.2	72.9	57.3	56.2	55.2	18.0	18.4	18.5	12.8	12.4	12.1

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

For research questions 3a and 3b only teachers with valid data on all the study variables were included in the sample. Because teacher survey data were not available until the 2014/15 school year, the analysis was limited to teachers employed from 2014/15 through 2016/17. Additionally, the sample included fewer novice teachers, because new teachers participated in the peer assistance and review process, which was mandatory for all new teachers who had not taught for at least three years in a public school district in the state. These teachers did not receive effectiveness scores in 2016/17, and therefore the sample of teachers for this year did not include teachers with less than three years of teaching experience in the state. Tables A8–A11 compare the characteristics of teachers included in the analytic sample for research questions 3a and 3b and the larger analytic sample included for research questions 2 and 3.

For all research questions the study team imputed any missing data for the following variables:

- *School demographic characteristics.* In 2015/16 and 2016/17, 54 percent of schools had student demographic data suppressed for at least one student subgroup because of the small number of students in a subgroup. To fill in the missing values, data were used for the closest year in which these data were available.
- *Teacher grade levels.* Between 2014/15 and 2016/17, 16 percent of teachers were missing information about grade-level assignment for at least one year. The study team coded these teachers as teaching in kindergarten–grade 5, grades 6–8, or grades 9–12. The codes were based on the grade levels served by the school in which the teachers were employed in the school year for which they were missing a grade-level assignment.

*Comparison of analytic samples.* Tables A8–A11 compare the characteristics and turnover rates of teachers in the larger sample used for research questions 2 and 3 with the more limited sample used for research questions 3a and 3b. Analyses for research questions 2 and 3 included all teachers employed from 2010/11 through 2016/17 (except for analyses that examined school characteristics or teacher effectiveness, which were limited to 2014/15 through 2016/17). For research questions 3a and 3b the sample was limited to teachers with data on all variables included in the analytic model. Therefore, the sample included only teachers employed from 2014/15 through 2016/17, when complete data on school characteristics and teacher effectiveness were available. Table A8 compares the demographic and professional characteristics of the two samples, and tables A9 and A10 compare the evaluation ratings and years of teaching in the district for teachers in the samples. Table A11 compares the turnover rates of teachers in both samples.

The two samples were similar across characteristics, except that the limited sample used for research questions 3a and 3b had fewer teachers with four or fewer years of teaching experience (17 percent) than the larger sample used for research questions 2 and 3 (26 percent; see table A10). This might be because more new teachers were placed in the peer assistance and review program in 2016/17 and therefore did not have effectiveness score data. This might also be because the percentage of teachers with four or fewer years of experience declined over the years of the study, with the highest percentages in the early years of 2010/11–2012/13 and the lowest percentages in 2014/15 and 2015/16 (see table A5). Likely as a result of having fewer new teachers, the percentage of teachers who left their school is lower among the sample for research questions 3a and 3b (16 percent) than for the sample for the other research questions (25 percent; see table A11). This may also be because the data included in research questions 3a and 3b were limited to school years 2014/15 through 2016/17, when teacher survey data were available, whereas turnover rates in the district were highest in 2010/11 and 2012/13, a period of district restructuring and budget shortfalls (see table B7).

**Table A8. Demographic and professional characteristics of teachers in the School District of Philadelphia, by analytic sample, 2010/11–2016/17 and 2014/15–2016/17**

Teacher characteristic	Research questions 2 and 3 (2010 /11–2016/17)		Research questions 3a and 3b (2014/15–2016/17)	
	Percent	Sample size <sup>a</sup>	Percent	Sample size <sup>a</sup>
<b>Gender</b>				
Male	26.2	59,126	25.6	19,418
Female	73.8	59,126	74.4	19,418
<b>Race/ethnicity</b>				
Black	25.5	59,102	25.0	19,418
Hispanic	2.9	59,102	3.2	19,418
White	68.1	59,102	68.3	19,418
Other race/ethnicity	3.4	59,102	3.5	19,418
<b>Subject taught</b>				
English language arts	50.7	49,650	49.1	16,591
Math	54.2	49,650	52.5	16,591
Science	47.5	49,650	46.4	16,591
Social studies	51.4	49,650	49.7	16,591
<b>Teaching assignment</b>				
General education	82.9	59,126	82.8	19,418
Special education	17.1	59,126	17.2	19,418
<b>Grade level taught</b>				
Elementary school grades (kindergarten–grade 5)	56.9	60,680	59.0	19,418
Middle school grades (6–8)	33.2	60,680	31.4	19,418
High school grades (9–12)	28.1	60,680	26.4	19,418
<b>Attendance</b>				
Regular (95 percent attendance or greater)	60.3	59,104	59.7	19,418
Frequently absent (75–94 percent attendance)	34.9	59,104	36.6	19,418
Less than 75 percent attendance	4.8	59,104	3.7	19,418

Teacher characteristic	Research questions 2 and 3 (2010 /11–2016/17)		Research questions 3a and 3b (2014/15–2016/17)	
	Percent	Sample size <sup>a</sup>	Percent	Sample size <sup>a</sup>
<b>Commute time</b>				
Shorter than 15 minutes	27.6	54,659	27.5	19,418
15–29 minutes	46.8	54,659	46.9	19,418
30–59 minutes	23.9	54,659	24.2	19,418
60 minutes or longer	1.8	54,659	1.4	19,418

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district during the years shown for each column).  
Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

**Table A9. Evaluation ratings among teachers in the School District of Philadelphia, by analytic sample, 2014/15–2016/17**

Teacher evaluation rating	Research questions 2 and 3		Research questions 3a and 3b	
	Percent	Sample size <sup>a</sup>	Percent	Sample size <sup>a</sup>
<b>PVAAS score<sup>b</sup></b>				
Failing or needs improvement (0–1.49) <sup>c</sup>	14.1	5,308	14.0	4,671
Proficient (1.5–2.49)	56.5	5,308	56.5	4,671
Distinguished (2.5–3)	29.5	5,308	29.5	4,671
<b>Teacher effectiveness score</b>				
Failing or needs improvement (0–1.49) <sup>c</sup>	4.1	22,216	4.2	19,418
Proficient (1.5–2.49)	84.0	22,216	84.0	19,418
Distinguished (2.5–3)	11.9	22,216	11.8	19,418

PVAAS is Pennsylvania Value-Added Assessment System.

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district from 2014/15 through 2016/17).  
b. In school years 2014/15 and 2015/16 teachers were assigned a categorical PVAAS score of 0, 1, 2, or 3. In school year 2016/17 PVAAS scores were calculated as a rolling average of the three previous years' PVAAS scores and therefore were a continuous measure.  
c. The bottom two evaluation rating categories (failing and needs improvement) were combined because of small sample sizes in the failing category.  
Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Table A10. Years of teaching among teachers in the School District of Philadelphia, by analytic sample, 2010/11–2016/17 and 2014/15–2016/17**

Years of teaching in the district	Research questions 2 and 3 (2010 /11–2016/17)		Research questions 3a and 3b (2014/15–2016/17)	
	Percent	Sample size <sup>a</sup>	Percent	Sample size <sup>a</sup>
4 or fewer years	25.5	60,812	17.0	19,418
5–10 years	27.0	60,812	30.8	19,418
11–17 years	23.9	60,812	29.5	19,418
More than 17 years	20.8	60,812	22.7	19,418

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district during the years shown for each column).  
Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

**Table A11. Teacher turnover in the School District of Philadelphia, by analytic sample and research question, 2010/11–2016/17 and 2014/15–2016/17 (percent of teachers unless otherwise indicated)**

Sample	Research questions 2 and 3 (2010/11–2016/17)	Research questions 3a and 3b (2014/15–2016/17)
Leaving their school for the full school year (Oct. to next Oct.)	24.8	16.3
Leaving their school within the school year (Oct. to Apr.)	2.8	0.4
Leaving their school between school years (Apr. to Oct.)	22.9	16.1
Leaving their school but not the district for the full school year	16.8	11.4
Leaving the district for the full school year	8.2	4.9
<b>Sample size (number)<sup>a</sup></b>	<b>60,268</b>	<b>19,419</b>

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district during the years shown for each column).  
Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

## Methodology

*Research question 1: How are teachers with different evaluation ratings distributed across schools in the district? Does student access to effective teachers vary between and within schools?* The study team examined the distribution of teacher effectiveness scores and PVAAS scores across the district by calculating an intraclass correlation (ICC), which reports the degree of variation across schools as a percentage of the total variation in teacher effectiveness scores in the district. The ICC measures how similar teachers are within their schools and how similar teachers within each school are to teachers in different schools across the district.

The study team also examined the distribution of effective of teachers by calculating the difference between the average effectiveness of teachers of economically disadvantaged, Black, and Hispanic students and the average effectiveness of teachers of non-economically disadvantaged and White students, a difference known as the effective teaching gap, or ETG (Isenberg et al., 2016). First, a district-level ETG was calculated as the average PVAAS score or effectiveness score of teachers of one group of students (economically disadvantaged, Black, or Hispanic) minus the average score of teachers of another group of students (non-economically disadvantaged or White). A simple regression was used for this calculation:

$$V_{jk} = \alpha + \delta SG_{jk} + e_{jk}$$

where  $V_{jk}$  is the PVAAS or effectiveness score of teacher  $j$ . Each teacher contributed two observations for a given subject and grade level: one for the subgroup ( $SG$ ) of interest (economically disadvantaged, Black, or Hispanic), labeled  $k = 1$  to represent the subgroup of interest ( $SG_{j1} = 1$ ), and one for the comparison group (non-economically disadvantaged or White), labeled  $k = 0$  to represent the comparison group ( $SG_{j0} = 0$ ). A teacher's score was the same for each observation ( $V_{j1} = V_{j0}$ ), and each observation was weighted by the total number of students of that subgroup. For example, a teacher who had 20 economically disadvantaged students and 10 non-economically disadvantaged students had weights of 20 and 10. The study team regressed  $V_{jk}$  on the binary variable  $SG_{jk}$ . The coefficient  $\delta$  measured the estimated difference in teacher scores between groups of students, with a positive value of  $\delta$  indicating that students in the subgroup of interest had teachers with higher scores, and a negative value of  $\delta$  indicating that students in the comparison group had teachers with higher scores on average.

The study team then calculated a between-school ETG and a within-school ETG. The between-school ETG can indicate whether, for example, economically disadvantaged students attended schools with less effective teachers on average than did non-economically disadvantaged students. The within-school ETG can indicate whether economically disadvantaged students are assigned to less effective teachers within schools. The between-school ETG was calculated by averaging the effectiveness score or PVAAS score of all teachers in a given grade at each school in SDP and assigning each student the average score of teachers in their grade at their school. Each teacher

was then assigned the average of their students' school grade-level scores. This average school grade-level score was used instead of each teacher's individual score in the regression model ( $V_{jk}$ ). As with the district-level ETG, each teacher contributed two observations for a given subject and grade level (one for each student group), and a teacher's score was the same for each observation. Each observation was weighted by the total number of students in each group. A positive  $\delta$  indicated that students in the subgroup of interest attended schools where teachers had higher scores, on average, and a negative  $\delta$  indicated that the students in the comparison group attended schools where teachers had higher scores. The within-school ETG was calculated as the difference between the overall district-level ETG based on teacher scores and the between-school ETG based on school scores.

The between-school and within-school ETGs can reinforce or offset each other. For example, they reinforce each other if economically disadvantaged students attend schools that have teachers with lower average scores and are assigned teachers with lower average scores within these schools. They offset each other if economically disadvantaged students attend schools that have teachers with lower average scores but are assigned teachers with higher average scores within these schools.

To allow for comparisons of ETGs across years and between PVAAS scores and effectiveness scores, the study team translated the ETGs into standard deviations of teacher PVAAS scores and effectiveness scores (see tables B3–B6 in appendix B). Standard deviations were calculated as the difference in the scores of teachers of two groups of students, divided by the standard deviation of all teachers' scores in the subject, grade, and year. One standard deviation in teachers' effectiveness scores was equal to 0.34 point, on average, across years, grades, and subjects (ranging from 0.30 point to 0.40 point). One standard deviation in PVAAS scores was equal to 0.69 point, on average (ranging from 0.61 point to 0.79 point).

Teachers' effectiveness scores combine multiple measures, including a school performance profile score and scores from classroom observations conducted by the school principal. Because the school performance profile score is the same for all teachers in a school and because school-specific observation practices may result in teachers' observation scores being more similar within the same school than across different schools, the inclusion of these measures could magnify differences in teacher effectiveness scores between schools and minimize differences within schools. This potential bias is lower for teachers with PVAAS scores because their effectiveness scores also include the PVAAS scores, a measure based only on student achievement growth.

To examine whether the inclusion of the school performance profile and observation scores biased the results for research question 1, the study team conducted a sensitivity analysis by limiting the analysis of effectiveness scores for research question 1 to teachers with PVAAS scores. The sensitivity analysis indicated that the results were not biased. The ICC results were of a similar magnitude, with 32 percent of the variation in effectiveness scores explained by differences between schools, on average. Between-school differences in average teacher effectiveness scores by student economic status and racial/ethnic identity were smaller across grade levels and subjects when the analysis was limited to teachers with PVAAS scores. The differences were about one-third the magnitude of differences when the analysis included all teachers with effectiveness scores. However, within-school differences were also smaller, indicating that differences in average teacher effectiveness scores continued to be driven by differences in average effectiveness scores between schools rather than by differences among the teachers assigned to students within schools. For analyses that included all teachers, within-school differences accounted for 15 percent of the total gap in average teacher effectiveness scores for grades 3–5 and 16 percent for grades 6–8 in math, and 21 percent for grades 3–5 and 30 percent for grades 6–8 in English language arts. For analyses that included only teachers with PVAAS scores, within-school differences accounted for less than 5 percent of the total gap across grade levels and subjects.

The analyses for research question 1 used teacher effectiveness scores and PVAAS scores because they provide a continuous measure of teacher effectiveness. Using them assumes that differences in effectiveness scores are meaningful, even for teachers with the same evaluation rating (failing, needs improvement, proficient, and distinguished). Because a large proportion of teachers receive the same rating (proficient), it is reasonable and useful to distinguish between teachers within categories using the underlying effectiveness score.

*Research question 2: What proportions of teachers leave their school and leave the district each year, both during the school year and between school years?* The study team calculated the turnover rate for each year as the percentage of teachers who left their school. This included teachers who changed schools, teachers who left teaching for a nonteaching position within the district, and teachers who left the district. In addition, the percentage of teachers who left their school but did not leave the district and the percentage of teachers who left the district were calculated separately.

The study team compared teachers' school assignments across employment time points to determine whether a teacher left a school, including changing schools or leaving teaching for a nonteaching position, during each study year. Teachers were classified as changing schools during the full school year if their school assignment changed between October 31 of one school year and October 31 of the following school year, and they were classified as changing schools within the school year if their school assignment changed between October 31 and April 1 within a school year. Teachers were classified as changing schools between school years if their school assignment changed between April 1 of one school year and October 31 of the following school year. For the same employment time points, teachers were classified as leaving teaching for a nonteaching position if they had a school assignment at one time point but did not have a school assignment at a future time point and were not recorded as having left SDP before April 1, 2017.

To determine whether a teacher left the school district, the study team used data from the Office of Talent Information Management on teachers who resigned, retired, or were terminated in each school year. Teachers were classified as leaving the school district during the full school year if they were recorded as leaving between October 31 of that school year and October 31 of the following school year. A teacher who left between October 31 and April 1 of a school year was classified as leaving the district within the school year. A teacher who left between April 1 of one school year and October 31 of the following school year was classified as leaving the district between school years.

To calculate overall turnover rates, the study team pooled all years of the data and examined turnover rates by teacher characteristics and teacher evaluation ratings. To examine differences in turnover by school characteristics, the study team compared, for each characteristic, the average among schools in which teachers who left their school had taught before leaving with the average among schools in which teachers who stayed in their school had taught. These calculations were repeated for schools in which teachers who left the district had taught before leaving and schools in which teachers who stayed in the district had taught.

*Research question 3: How does teaching experience relate to whether teachers leave their school or leave the district?* For research question 3 the study team used a survival analysis to examine the likelihood that teachers would leave their school during the years in which they were observed teaching in that school or would leave the district over the course of their career in the district. The survival analysis examined the amount of time until a teacher left a school or left the district and calculated the rate at which teachers left at any given point during their time in a school or in the district. The study reports the failure function, which is the cumulative probability that teachers would leave their school or leave the district over time, and the hazard rate for each year, which is the rate at which teachers left their school or left the district at each time point.

Time was measured in days, beginning with a teacher's hire date in the district and ending at the date the teacher left the district or the last date at which the teacher was observed in the data. Teachers' employment status was

observed at three points in each school year: September 1, October 31, and April 1. The first possible date when a teacher could have been observed was September 1, 2010, and the last possible date was April 1, 2017. To account for the fact that the study could not observe teachers who left the district before September 1, 2010, teachers contributed to the analysis only for the years of teaching in which they were observed. For example, a teacher who was hired in September 2005 would be included in the analysis starting at five years of teaching (September 2010), which is the point in the teacher's career at which the study could observe whether the teacher left the school or left the district. If this teacher left in August 2015 (at 10 years of teaching), the teacher would be included in calculating the probability of a teacher leaving between 5 and 10 years of teaching. This teacher would not be included in calculating the probability of a teacher leaving between 1 and 4 years of teaching because the teacher was not observed during those years.

The study team conducted two survival analyses: an analysis of the probability that a teacher would leave a school over the years teaching in a school and an analysis of the probability that a teachers would leave the district over the years employed in the district. Each analysis is summarized below. The study team decided not to analyze the factors related to a teacher's decision to move within the district, excluding teachers who left the district. When a teacher leaves a school, it can disrupt the school community and requires spending resources to hire a replacement teacher, regardless of whether the teacher leaves for another school in the district or leaves the district.

*Analysis of teachers who leave their school.* As described in the methodology for research question 2, the study team compared teachers' school assignments across time points to determine whether a teacher left a school during each study year. The date of a teacher's last time point employed at a school was used as the date the teacher left the school. For example, if a teacher was employed in School A on April 1, 2015, and employed at School B on September 1, 2015, that teacher was considered to have left School A on April 1, 2015. For teachers who left the district, the study team used the date the teacher left—obtained from the Office of Talent Information Management's data file on teachers who resigned, retired, or were terminated in each school year—as the date that the teacher left a school. Teachers with a final time point employed in a school that was before April 1, 2017, but who were not recorded as leaving the district were also considered to have left their school because these teachers might have moved into a nonteaching position within the district. For these teachers the last time point employed at a school was used as the date the teacher left the school.

To account for the fact that teachers could change schools multiple times during their careers, time was measured beginning with a teacher's hire date in the district for the first school in which the teacher was employed and, for subsequent schools, at the date of the first time point at which the teacher was employed in the school. For example, if a teacher was first observed at School A in September 2010 and then moved to School B in April 2013, time was measured from the teacher's hire date for the teacher's tenure in School A and then measured again from April 2013 for the teacher's tenure in School B. This approach allowed the analysis to include multiple school moves and examine teacher turnover by the amount of time a teacher was employed in a school. The study team chose this approach because it is likely most useful for school principals to understand the probability that a teacher will leave the school within the context of how long the teacher has taught at that school, rather than how long the teacher has been employed in the district. Thirty-six percent of teachers changed schools at least once during the study period. This analysis included 174,373 teacher employment observations representing 21,999 teacher-school combinations and 14,578 teachers.

*Analysis of teachers who leave the district.* As described above for research question 2, the study team used data from the Office of Talent Information Management on teachers who resigned, retired, or were terminated in each school year to determine whether a teacher left the district. The date the teacher left the district was the date recorded in the data file. The survival analysis of teachers leaving the district included 188,731 teacher employment observations representing 14,967 teachers.

*Research question 3a: What other teacher and school characteristics are related to teachers leaving their school or leaving the district?* For research questions 3a and 3b the study team used a Cox proportional hazards model, which analyzes the factors associated with the occurrence and timing of events (Kalbfleisch & Prentice, 2002; Singer & Willett, 2003). As with the survival analysis, the study team used the Cox proportional hazards model to examine which teacher and school characteristics were related to two types of events: teachers leaving a school and teachers leaving the district. Only teachers with complete data across all time points were included in the hazards models, which limited the sample to school years 2014/15 through 2016/17; sample sizes are provided below in the description of each hazards model.

For both hazards models the study team examined correlations between independent variables to assess potential collinearity before fitting each hazards model. After fitting each model, the study team tested the proportional hazards assumption that the change in risk with each covariate is constant over time. This assumption might be violated if, for example, a variable increases a teacher's risk of leaving in the first five years of teaching but then has no effect on leaving later in a teacher's tenure. The proportional hazards assumption was tested using Schoenfeld residuals, which calculate the difference between the value of a variable at the time a teacher leaves and the average value of that variable among all teachers who have not left by that time point (Cleves et al., 2016; Singer & Willett, 2003). Schoenfeld residuals detect a violation of the proportional hazards assumption by examining whether differences increase or decrease over time (indicating a violation) or stay the same (indicating no violation). In the example above a larger difference would exist between the value of the variable for teachers who leave and the average value for teachers who stay during the first five years of teaching than in subsequent years, indicating a violation of the assumption.

*Hazards model specifications for teachers who left a school.* The date of the last time point at which a teacher was employed at a school, or the date the teacher left the district (if the teacher left the district), was used as the date the teacher left a school. Time was measured in days from the hire date in the district for the first school at which a teacher was observed until the teacher left the school or left the district. For teachers who changed schools during the study period, time began again, starting with day zero, at the date of the first time point at which a teacher was observed at each subsequent school.

The model accounted for the date at which teachers were first observed in the data and used robust standard errors clustered at the teacher level. The independent variables used in the hazards model are in table B15 in appendix B and include a variable accounting for the number of times a teacher had previously changed schools. Forty-three percent of teachers changed schools at least once during the study period. No variables violated the proportional hazards assumption. The hazards model for teachers leaving a school included 48,052 teacher-employment observations representing 9,219 teacher-school combinations and 8,138 teachers.

*Hazards model specifications for teachers leaving the district.* Time was measured in days from the hire date in the district until the date the teacher left the district. The model also specified the date at which teachers were first observed in the data. Robust standard errors were clustered at the teacher level. The independent variables used in the hazards model are in table B15 in appendix B. The hazards model for teachers leaving the district included 50,147 teacher employment observations representing 8,147 teachers.

For this model the retirement eligibility variable violated the proportional hazards assumption, meaning that its influence over teachers' probability of leaving changed over time. This is not surprising. Teachers typically become eligible for retirement near the end of their career, so retirement eligibility would have no effect early in a teacher's career. To adjust for this, the study team estimated a model interacting retirement eligibility with time. This model provided a slightly better fit; however, the report uses results from the model without the time-dependent effects for ease of explanation. The results with time-dependent effects are in table B17 in appendix B. Results from the model with time-dependent effects are similar to results from the model without them. The same characteristics are significantly related to the probability of teachers leaving the district in both models.

Coefficients in both models did not differ for 8 of the characteristics and were similar for the remaining 13 characteristics.

*Research question 3b: Does the relationship between teacher and school characteristics and turnover differ between effective teachers and ineffective teachers?* To examine whether the relationship between teacher and school characteristics and teacher turnover differed, the study team interacted a variable indicating whether a teacher was rated proficient or distinguished with each of the independent variables in the hazards model. The team then examined whether the relationship between each variable and teachers' likelihood of leaving was both significantly and substantively different between teachers with high or low evaluation ratings.

### ***Limitations***

*Data availability.* The study team's analysis of characteristics related to turnover was limited to characteristics measured in the data the district provided. Although data captured several important teacher and school factors, other unmeasured factors could have influenced teacher turnover, such as teachers' induction or mentoring programs, teachers' preparation, and teachers' prior experience with similar student populations.

*Constructs from the teacher survey data.* Teacher survey results may not be representative at the school level because of low response rates overall and at some schools (see description of survey response rates above). Response rates were not related to schools' academic performance or student demographics. Smaller schools had higher response rates, so survey results may be more representative of teachers in smaller schools than teachers in larger schools. Higher response rates were related to more positive teacher responses on the survey, indicating that survey results may be more representative of teachers at schools with a more positive school climate. However, response rates might provide a measure of the level of teacher engagement at a school, suggesting that low response rates could reflect a less positive school climate. While the teacher survey results might differ if response rates were higher, the survey results still provide a useful and unique measure of teachers' perspectives about their school that can inform SDP's policies.

In addition, the study team did not assess the reliability and validity of the survey constructs used in the analysis. However, these constructs are closely aligned with survey constructs that SDP created and assessed for reliability and validity (School District of Philadelphia, 2018).

*The construction of teacher effectiveness and PVAAS scores.* Teacher effectiveness scores in the district combine multiple measures and may include scores from principal observations of teacher practice, PVAAS scores, scores based on student learning objectives, and a school performance profile intended to capture a school's overall performance. Each of these measures could introduce bias that would affect the analysis of research question 1 and potentially overstate differences in teacher effectiveness between schools and between groups of students. A school receives one performance profile score that is applied to all teachers in that school and is based on a combination of academic and nonacademic measures, including student scores on state assessments, graduation or promotion rates, and attendance rates. The inclusion of this measure and observation scores that might be influenced by school-specific practices could bias the results for research question 1 by magnifying differences in average effectiveness scores between schools and minimizing differences within schools. As described in the methodology section, a sensitivity analysis indicated that the inclusion of school performance profile and observation scores did not bias the results for research question 1. Other research also indicates that observation measures may be biased, with teachers of economically disadvantaged students and students of color more likely to receive lower observation scores than teachers of non—economically disadvantaged students or White students (Campbell & Ronfeldt, 2018; Steinberg & Garrett, 2016; Whitehurst et al., 2014). This bias could lead to overestimating differences in the quality of teachers of different groups of students in the analysis of research question 1.

Similarly, PVAAS scores could overestimate differences in teacher quality because they do not include controls for some student characteristics, such as special education status and English learner status, and do not account for the effects of a student's classmates on the achievement of that student in a classroom or for the effects of the clustering of similar types of students within schools and classrooms (Kane, 2017; McCaffrey & Buzick, 2014; Isenberg et al., 2016). In addition, PVAAS scores are calculated as a point estimate divided by the standard error of the measure. Teachers of economically disadvantaged students might have less precise scores, and therefore larger standard errors, because it is more difficult to accurately predict the future achievement of these students (Hermann et al., 2016). Therefore, teachers of economically disadvantaged students might be less likely to receive very high or very low PVAAS scores.

To address potential bias and limitations in the effectiveness scores and PVAAS scores, the report presents results using both measures of teacher effectiveness and discusses similarities and differences in the findings.

*Applying findings to all district teachers.* The analysis of the combined influence of teacher and school characteristics on the likelihood of teacher turnover could include only teachers with complete data across all school years. This limited the years included in the analysis to 2014/15 through 2016/17, meaning that the findings apply only to teachers employed in more recent years. Most of the characteristics of teachers included in this analysis were similar to the characteristics of teachers included in the analysis of other research questions, except that these teachers were slightly more experienced than the overall teacher population. Thus, findings may be more applicable to more experienced teachers (see tables A8–A11).

Analyses using PVAAS score data cannot generalize to all district teachers because only teachers who taught math and English language arts in grades 4–8 received PVAAS scores.

Finally, the district experienced higher teacher turnover in 2010/11, because of a districtwide initiative converting schools to charter schools, and in 2012/13, because a budget shortfall that led to staff layoffs and school closings. Therefore, analyses that include these school years may not reflect teacher turnover in years without these events.

*Macroeconomic influences on the district's workforce.* The study included school years 2010/11 through 2016/17, which includes the 2008 recession and recovery period. The economic environment varied substantially over the study time period. The unemployment rate in the Philadelphia area declined from 8.4 percent in September 2010 to 4.4 percent in April 2017 (U.S. Department of Labor, 2019). Changing economic conditions could influence teacher turnover, including the district's ability to hire new teachers and retain existing teachers. The study does not take into account the potential influence of the economy on teacher turnover; therefore, findings might differ in another economic environment.

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## Appendix B. Supporting analyses

This appendix includes tables that support the study findings presented in the main report.

### ***Research question 1: How are teachers with different evaluation ratings distributed across schools in the district? Does student access to effective teachers vary between and within schools?***

This section presents results for research question 1 by school year and subject area for findings summarized in the main report and presents findings from additional analyses not discussed in the main report.

*The relationship between teacher experience and evaluation rating.* About 9 percent of teachers with 4 or fewer years of experience in the district were rated distinguished based on their effectiveness score, while 14 percent of teachers with more than 17 years of experience were rated distinguished (table B1). Teachers with four or fewer years of experience were about as likely as teachers with more experience to be rated failing or needs improvement (5 percent compared with 4 percent). The results were similar for Pennsylvania Value-Added Assessment System (PVAAS) scores: teachers with four or fewer years of experience were less likely than teachers with more experience to be rated distinguished.

**Table B1. Evaluation ratings among teachers in the School District of Philadelphia, by effectiveness measure and by years of teaching experience, 2014/15–2016/17**

Effectiveness measure and evaluation rating	Overall		Years of teaching experience (percent of teachers)			
	Percent	Sample size <sup>a</sup>	4 or fewer years	5–10 years	11–17 years	More than 17 years
<b>Teacher effectiveness score</b>						
Failing or needs improvement (0–1.49) <sup>b</sup>	4.1	22,216	5.1	3.9	4.0	3.9
Proficient (1.5–2.49)	84.0	22,216	86.1	84.0	83.9	81.9
Distinguished (2.5–3)	11.9	22,216	8.8	12.1	12.0	14.2
Average effectiveness score	2.06	22,216	2.02	2.07	2.06	2.09
<b>Pennsylvania Value-Added Assessment System (PVAAS) score</b>						
Failing or needs improvement (0–1.49)	7.2	4,423	12.8	6.4	5.3	6.1
Proficient (1.5–2.49)	60.9	4,423	61.7	61.9	61.4	58.1
Distinguished (2.5–3)	31.9	4,423	25.5	31.7	33.3	35.8
Average PVAAS score	2.21	4,423	2.05	2.22	2.26	2.26

Note: Observations are by teacher-year. PVAAS data include school years 2014/15 and 2015/16.

a. The number of teacher-years included in the analysis (teachers multiplied by their years employed in the district from 2010/11 through 2016/17).

b. The bottom two evaluation rating categories (failing and needs improvement) were combined because of small sample sizes in the failing category.

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

*The distribution of effective teachers across the district.* Table B2 presents findings from the analysis of the distributions of teacher effectiveness scores and PVAAS scores across the district. Because results are consistent across school years and grade levels, the main report presents a weighted average across all years and grades. This section provides detailed findings by school year and grade level.

As described in the main report and appendix A, the study team calculated a measure of how similar teachers were within the same school and how similar each school's average teacher was to the average teacher at other schools. This measure, the intraclass correlation, reports the percentage of the total range of teacher effectiveness scores or PVAAS scores that can be explained by differences between each school's average teacher. An intraclass correlation of 0 percent indicates that teacher effectiveness is perfectly distributed across schools and that each school has the same average teacher effectiveness score or PVAAS score. An intraclass correlation of 100 percent indicates that each school has a different average teacher effectiveness score or PVAAS score and that all teachers within a school have the same score. For example, for elementary school teachers 8–18 percent of the variation

in teachers' PVAAS scores was explained by differences between schools. By comparison, 22–34 percent of the variation in teachers' effectiveness scores was explained by differences between schools. This means that there were larger differences between schools in average teacher effectiveness scores than in average PVAAS scores.

**Table B2. Between-school differences in the percentage of total variation in teacher evaluation scores in the School District of Philadelphia, by grade level and school year, 2014/15–2016/17**

Year	Teacher effectiveness score		PVAAS score	
	Intraclass correlation coefficient (95% confidence interval)	Number of teachers	Intraclass correlation coefficient (95% confidence interval)	Number of teachers
<b>Elementary school teachers (kindergarten–grade 5)</b>				
2014/15	0.28 (0.23, 0.34)	3,371	0.18 (0.12, 0.24)	1,208
2015/16	0.22 (0.17, 0.27)	3,575	0.10 (0.06, 0.15)	1,320
2016/17	0.34 (0.28, 0.40)	3,219	0.08 (0.00, 0.19)	425
<b>Middle school teachers (grades 6–8)</b>				
2014/15	0.34 (0.27, 0.42)	1,614	0.24 (0.17, 0.30)	1,300
2015/16	0.23 (0.17, 0.30)	1,661	0.16 (0.11, 0.22)	1,364
2016/17	0.39 (0.31, 0.47)	1,489	0.20 (0.10, 0.30)	490
<b>High school teachers (grades 9–12)</b>				
2014/15	0.36 (0.24, 0.47)	1,851	na	na
2015/16	0.37 (0.26, 0.49)	1,862	na	na
2016/17	0.36 (0.25, 0.47)	1,775	na	na

PVAAS is Pennsylvania Value-Added Assessment System. ICC is intraclass correlation coefficient. n.a. is not applicable.

Note: PVAAS scores are available only for teachers in grades 4–8; therefore, there is no PVAAS intraclass correlation coefficient for high school teachers, and the PVAAS intraclass correlation coefficient for elementary school teachers includes only teachers in grades 4 and 5.

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

*Differences in the average effectiveness of teachers of economically disadvantaged, Black, and Hispanic students and teachers of non–economically disadvantaged and White students.* Tables B3–B6 present findings from the effective teaching gap (ETG) analysis by school year, grade level, and measure of teacher effectiveness for three types of ETGs:

- Between-school ETG, which indicates whether one group of students attends schools with less effective teachers, on average.
- Within-school ETG, which indicates whether one group of students is assigned to less effective teachers within schools.

- District-level ETG, which describes the overall difference between the average effectiveness of teachers of one group of students (economically disadvantaged, Black, or Hispanic) compared with teachers of another group (non-economically disadvantaged or White).

To enable comparisons across years, grade levels, and measures of teacher effectiveness, results are presented in standard deviations of teachers' scores (calculated as the difference in the scores of teachers of two groups of students, divided by the standard deviation of all teachers' scores). A negative ETG indicates that non-economically disadvantaged or White students had teachers with higher scores on average than economically disadvantaged, Black, or Hispanic students. A positive ETG indicates that economically disadvantaged, Black, or Hispanic students had teachers with higher scores.

**Table B3. Effective teaching gap in math in grades 3–5 in the School District of Philadelphia, by effectiveness measure, student group, and school year, 2014/15–2016/17**

Effectiveness measure, student group, and school year	Number of teachers	Number of schools	Effective teaching gap (standard deviation)				
			Between schools	Within schools	Overall district		
<b>Gap in teacher effectiveness scores</b>							
<i>Economically disadvantaged students relative to non–economically disadvantaged students</i>							
2014/15	1,308	158	-0.22 <sup>††</sup>	-0.04	-0.26 <sup>††</sup>		
2015/16	1,292	157	-0.13 <sup>†</sup>	0.01	-0.13 <sup>†</sup>		
2016/17	1,168	157	-0.41 <sup>††</sup>	0.07	-0.33 <sup>††</sup>		
<i>Black students relative to White students</i>							
2014/15	1,282	158	-0.56 <sup>††</sup>	-0.07	-0.63 <sup>††</sup>		
2015/16	1,254	157	-0.47 <sup>††</sup>	0.09 <sup>†</sup>	-0.39 <sup>††</sup>		
2016/17	1,136	156	-0.99 <sup>††</sup>	0.23 <sup>††</sup>	-0.76 <sup>††</sup>		
<i>Hispanic students relative to White students</i>							
2014/15	1,054	153	-0.62 <sup>††</sup>	0.03	-0.60 <sup>††</sup>		
2015/16	1,049	155	-0.35 <sup>††</sup>	0.04	-0.30 <sup>††</sup>		
2016/17	969	153	-0.56 <sup>††</sup>	0.05	-0.51 <sup>††</sup>		
<b>Gap in teacher PVAAS scores</b>							
<i>Economically disadvantaged students relative to non–economically disadvantaged students</i>							
2014/15	673	158	-0.07	-0.01	-0.08		
2015/16	636	157	-0.06	0.01	-0.05		
2016/17	344	156	-0.14 <sup>†</sup>	-0.11	-0.24 <sup>†</sup>		
<i>Black students relative to White students</i>							
2014/15	666	158	-0.15 <sup>†</sup>	-0.03	-0.18 <sup>†</sup>		
2015/16	623	157	-0.28 <sup>††</sup>	0.08	-0.20 <sup>†</sup>		
2016/17	341	155	-0.20 <sup>†</sup>	-0.22 <sup>†</sup>	-0.42 <sup>††</sup>		
<i>Hispanic students relative to White students</i>							
2014/15	551	150	-0.38 <sup>††</sup>	0.07	-0.30 <sup>††</sup>		
2015/16	546	152	-0.22 <sup>†</sup>	0.03	-0.19 <sup>†</sup>		
2016/17	297	152	-0.08	-0.20 <sup>†</sup>	-0.28 <sup>††</sup>		

PVAAS is Pennsylvania Value-Added Assessment System.

<sup>†</sup> Effective teaching gap (ETG) is more than half the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching.

<sup>††</sup> ETG is larger than the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching (0.17 standard deviation for effectiveness scores and 0.26 standard deviation for PVAAS scores).

Note: PVAAS scores are available only for teachers in grades 4 and 5.

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Table B4. Effective teaching gap in English language arts in grades 3–5 in the School District of Philadelphia, by effectiveness measure, student group, and school year, 2014/15–2016/17**

Effectiveness measure, student group, and school year	Number of teachers	Number of schools	Between schools	Within schools	Effective teaching gap (standard deviation) Overall district
<b>Gap in teacher effectiveness scores</b>					
<i>Economically disadvantaged students relative to non–economically disadvantaged students</i>					
2014/15	1,423	159	−0.24 <sup>++</sup>	0.01	−0.24 <sup>++</sup>
2015/16	1,423	158	−0.18 <sup>++</sup>	0.03	−0.15 <sup>†</sup>
2016/17	1,279	156	−0.34 <sup>++</sup>	0.06	−0.28 <sup>++</sup>
<i>Black students relative to White students</i>					
2014/15	1,381	159	−0.55 <sup>++</sup>	−0.01	−0.56 <sup>++</sup>
2015/16	1,362	157	−0.51 <sup>++</sup>	0.19 <sup>++</sup>	−0.33 <sup>++</sup>
2016/17	1,231	155	−0.89 <sup>++</sup>	0.25 <sup>++</sup>	−0.64 <sup>++</sup>
<i>Hispanic students relative to White students</i>					
2014/15	1,153	154	−0.61 <sup>++</sup>	0.00	−0.61 <sup>++</sup>
2015/16	1,160	156	−0.44 <sup>++</sup>	0.10 <sup>†</sup>	−0.34 <sup>++</sup>
2016/17	1,073	153	−0.55 <sup>++</sup>	0.07	−0.48 <sup>++</sup>
<b>Gap in teacher PVAAS scores</b>					
<i>Economically disadvantaged students relative to non–economically disadvantaged students</i>					
2014/15	709	158	−0.05	−0.01	−0.06
2015/16	705	158	−0.10	0.02	−0.07
2016/17	359	156	−0.14 <sup>†</sup>	−0.10	−0.23 <sup>†</sup>
<i>Black students relative to White students</i>					
2014/15	698	158	0.03	−0.11	−0.08
2015/16	687	157	−0.34 <sup>++</sup>	0.16 <sup>†</sup>	−0.18 <sup>†</sup>
2016/17	357	155	−0.21 <sup>†</sup>	−0.25 <sup>†</sup>	−0.46 <sup>++</sup>
<i>Hispanic students relative to White students</i>					
2014/15	583	150	−0.34 <sup>++</sup>	0.14 <sup>†</sup>	−0.21 <sup>†</sup>
2015/16	597	153	−0.38 <sup>++</sup>	0.15 <sup>†</sup>	−0.23 <sup>†</sup>
2016/17	307	152	−0.19 <sup>†</sup>	−0.17 <sup>†</sup>	−0.35 <sup>++</sup>

PVAAS is Pennsylvania Value-Added Assessment System.

<sup>†</sup> Effective teaching gap (ETG) is more than half the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching.

<sup>++</sup> ETG is larger than the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching (0.17 standard deviation for effectiveness scores and 0.26 standard deviation for PVAAS scores).

Note: PVAAS scores are available only for teachers in grades 4 and 5.

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Table B5. Effective teaching gap in math in grades 6–8 in the School District of Philadelphia, by effectiveness measure, student group, and school year, 2014/15–2016/17**

Effectiveness measure, student group, and school year	Number of teachers	Number of schools	Effective teaching gap (standard deviation)				
			Between schools	Within schools	Overall district		
<b>Gap in teacher effectiveness scores</b>							
<i>Economically disadvantaged students relative to non-economically disadvantaged students</i>							
2014/15	631	146	-0.22 <sup>††</sup>	-0.08	-0.30 <sup>††</sup>		
2015/16	595	141	-0.24 <sup>††</sup>	0.02	-0.21 <sup>††</sup>		
2016/17	512	142	-0.47 <sup>††</sup>	0.09	-0.38 <sup>††</sup>		
<i>Black students relative to White students</i>							
2014/15	609	144	-0.72 <sup>††</sup>	-0.05	-0.77 <sup>††</sup>		
2015/16	585	140	-0.50 <sup>††</sup>	0.06	-0.43 <sup>††</sup>		
2016/17	494	140	-0.79 <sup>††</sup>	0.11 <sup>†</sup>	-0.69 <sup>††</sup>		
<i>Hispanic students relative to White students</i>							
2014/15	481	126	-0.42 <sup>††</sup>	-0.05	-0.48 <sup>††</sup>		
2015/16	474	124	-0.42 <sup>††</sup>	0.05	-0.38 <sup>††</sup>		
2016/17	425	130	-0.67 <sup>††</sup>	0.13 <sup>†</sup>	-0.55 <sup>††</sup>		
<b>Gap in teacher PVAAS scores</b>							
<i>Economically disadvantaged students relative to non-economically disadvantaged students</i>							
2014/15	441	146	-0.11	-0.02	-0.13 <sup>†</sup>		
2015/16	409	141	-0.23 <sup>†</sup>	0.12	-0.11		
2016/17	236	142	-0.24 <sup>†</sup>	-0.03	-0.27 <sup>††</sup>		
<i>Black students relative to White students</i>							
2014/15	436	144	-0.41 <sup>††</sup>	-0.07	-0.48 <sup>††</sup>		
2015/16	404	140	-0.53 <sup>††</sup>	0.34 <sup>††</sup>	-0.18 <sup>†</sup>		
2016/17	234	140	-0.48 <sup>††</sup>	-0.04	-0.52 <sup>††</sup>		
<i>Hispanic students relative to White students</i>							
2014/15	356	126	-0.10	-0.15 <sup>†</sup>	-0.25 <sup>†</sup>		
2015/16	355	124	-0.56 <sup>††</sup>	0.26 <sup>††</sup>	-0.30 <sup>††</sup>		
2016/17	217	130	-0.38 <sup>††</sup>	0.02	-0.36 <sup>††</sup>		

PVAAS is Pennsylvania Value-Added Assessment System.

<sup>†</sup> Effective teaching gap (ETG) is more than half the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching.

<sup>††</sup> ETG is larger than the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching (0.20 standard deviation for effectiveness scores and 0.26 standard deviation for PVAAS scores).

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Table B6. Effective teaching gap in English language arts in grades 6–8 in the School District of Philadelphia, by effectiveness measure, student group, and school year, 2014/15–2016/17**

Effectiveness measure, student group, and school year	Number of teachers	Number of schools	Effective teaching gap (standard deviation)				
			Between schools	Within schools	Overall district		
<b>Gap in teacher effectiveness scores</b>							
<i>Economically disadvantaged students relative to non-economically disadvantaged students</i>							
2014/15	720	144	-0.38 <sup>††</sup>	0.02	-0.36 <sup>††</sup>		
2015/16	676	142	-0.36 <sup>††</sup>	0.09	-0.27 <sup>††</sup>		
2016/17	595	141	-0.53 <sup>††</sup>	0.18 <sup>†</sup>	-0.34 <sup>††</sup>		
<i>Black students relative to White students</i>							
2014/15	686	143	-0.75 <sup>††</sup>	0.10 <sup>†</sup>	-0.65 <sup>††</sup>		
2015/16	648	141	-0.62 <sup>††</sup>	0.13 <sup>†</sup>	-0.48 <sup>††</sup>		
2016/17	570	138	-1.20 <sup>††</sup>	0.53 <sup>††</sup>	-0.67 <sup>††</sup>		
<i>Hispanic students relative to White students</i>							
2014/15	557	124	-0.63 <sup>††</sup>	0.07	-0.57 <sup>††</sup>		
2015/16	530	125	-0.60 <sup>††</sup>	0.01	-0.59 <sup>††</sup>		
2016/17	498	130	-0.82 <sup>††</sup>	0.25 <sup>††</sup>	-0.57 <sup>††</sup>		
<b>Gap in teacher PVAAS scores</b>							
<i>Economically disadvantaged students relative to non-economically disadvantaged students</i>							
2014/15	482	144	-0.22 <sup>†</sup>	0.10	-0.13 <sup>†</sup>		
2015/16	449	142	-0.28 <sup>††</sup>	0.09	-0.19 <sup>†</sup>		
2016/17	248	141	-0.16 <sup>†</sup>	-0.06	-0.22 <sup>†</sup>		
<i>Black students relative to White students</i>							
2014/15	474	143	-0.56 <sup>††</sup>	0.24 <sup>†</sup>	-0.31 <sup>††</sup>		
2015/16	438	141	-0.50 <sup>††</sup>	0.17 <sup>†</sup>	-0.32 <sup>††</sup>		
2016/17	245	138	-0.41 <sup>††</sup>	-0.07	-0.48 <sup>††</sup>		
<i>Hispanic students relative to White students</i>							
2014/15	395	124	-0.45 <sup>††</sup>	0.24 <sup>†</sup>	-0.21 <sup>†</sup>		
2015/16	379	125	-0.51 <sup>††</sup>	-0.01	-0.52 <sup>††</sup>		
2016/17	223	130	-0.36 <sup>††</sup>	0.02	-0.34 <sup>††</sup>		

PVAAS is Pennsylvania Value-Added Assessment System.

<sup>†</sup> Effective teaching gap (ETG) is more than half the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching.

<sup>††</sup> ETG is larger than the difference in scores between teachers in their first four years of teaching and teachers with five or more years of teaching (0.20 standard deviation for effectiveness scores and 0.26 standard deviation for PVAAS scores).

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Research question 2: What proportions of teachers leave their school and leave the district, both during the school year and between school years?**

The main report presents findings on teacher turnover in each school year and by teacher and school characteristics for characteristics that had differences between groups of at least 5 percentage points and that had the largest relationship with teacher turnover based on the analyses for research question 3. This section presents teacher turnover rates by teacher and school characteristics by school year and for additional teacher and school characteristics not included in the main report.

*Teacher turnover by school year.* Table B7 presents the percentage of teachers who left their school during the full year, within each school year, and between school years. The percentage of teachers leaving during the full year remained consistent at around 20–22 percent across school years, except in 2010/11, during the districtwide initiative that converted public schools to charter schools, and in 2012/13, during the budget shortfall (as discussed in the main report). In those two years the percentage of teachers leaving increased. Teachers left primarily between school years; the percentage of teachers leaving within the school year did not change substantially over the school years in the study.

Table B7 also presents the percentage of teachers who left their school but remained in the district during each school year and the percentage who left the district. A higher percentage of teachers changed schools within the district during each year than left the district. Again, there were increases in both teachers changing schools and teachers leaving the district in 2010/11 and 2012/13.

**Table B7. Teacher turnover in the School District of Philadelphia, by school year, 2010/11–2016/17 (percent of teachers leaving their school or the district)**

School year	Number of teachers	Leaving during the full year (Oct. to Oct.)	Leaving within the school year (Oct. to Apr.)	Leaving between school years (Apr. to Oct.)	Leaving their school but not the district during full year	Leaving the district during full year
2010/11	10,054	32.8	3.2	30.9	21.9	11.3
2011/12	9,038	21.3	2.4	19.5	14.8	6.6
2012/13	8,824	31.6	2.2	30.3	21.3	10.4
2013/14	8,137	22.6	2.6	20.9	15.5	7.2
2014/15	8,061	20.3	3.2	17.9	13.6	6.8
2015/16	8,015	22.9	3.0	20.6	15.7	7.2
2016/17	8,139	20.3	3.2	18.0	12.9	7.5
All school years	60,268	24.8	2.8	22.9	16.8	8.2
2014/15–2016/17	24,215	21.2	3.1	18.8	14.1	7.2

Note: The percentage of teachers leaving within the school year and the percentage leaving between school years do not sum to the percentage leaving during the full year because some teachers might have left their school within the school year and then changed schools again between school years. In these cases the teacher is included in both the within the school year and between school years columns but is counted only once in the full year column. Similarly, the percentage of teachers leaving their school but not the district and the percentage of teachers leaving the district do not always sum to the total percentage leaving during the full year because some teachers might have changed schools during the school year and also left the district during the same school year. In these cases the teacher is included in both the percentage of teachers leaving their school but not the district and in the percentage of teachers leaving the district columns but is counted only once in the full year column.

Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

*Teacher turnover by teacher characteristic and school year.* Table B8 presents teacher turnover by teacher characteristics and by school year for the characteristics discussed in the main report. It also includes turnover for other teacher characteristics that did not have differences between groups of teachers of at least 5 percentage points or that did not have a sufficiently large relationship with teacher turnover based on the analyses conducted

for research question 3 to be included in the main report. Table B9 presents the percentage of teachers leaving the district by all teacher characteristics and by school year. Tables B10 and B11 show the percentages of teachers leaving their school and leaving the district by teacher evaluation rating and by school year.

**Table B8. Percentage of teachers leaving their school in the School District of Philadelphia, by teacher characteristic and school year, 2010/11–2016/17**

Teacher characteristic	Overall									
	Percent leaving	Sample size <sup>a</sup>	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	
Overall	24.8	60,268	32.8	21.3	31.6	22.6	20.3	22.9	20.3	
<b>Years teaching in the district</b>	†		†	†	†	†	†	†	†	
Four or fewer years	37.2	15,372	47.9	31.0	43.5	31.3	29.7	33.2	31.0	
5–10 years	19.9	16,369	19.5	16.4	22.3	21.0	19.6	23.6	16.5	
11–17 years	16.7	14,501	18.4	13.3	21.9	17.5	14.3	16.8	15.3	
More than 17 years	21.5	12,595	28.6	18.0	33.3	17.8	17.5	17.7	15.8	
<b>Race/ethnicity</b>			†					†		
Black	24.6	15,002	30.6	20.1	32.4	22.6	19.0	23.6	21.7	
Hispanic	25.1	1,703	32.7	22.8	28.4	25.0	20.7	25.8	19.5	
White	23.6	40,078	31.8	20.6	30.1	21.1	19.3	21.4	18.9	
Other race/ethnicity	25.2	2,031	38.1	20.6	28.6	24.1	20.7	18.9	22.1	
<b>Gender</b>			†		†					
Female	22.8	43,468	29.2	19.4	28.9	21.3	18.6	21.4	19.4	
Male	27.3	15,370	38.4	23.6	35.6	22.7	21.6	23.9	21.1	
<b>Subject taught, grades 6–8</b>										
Math/science	28.2	5,724	25.7	27.8	35.6	28.3	25.5	29.5	24.0	
English language arts/social studies	27.8	6,006	26.1	25.6	34.7	26.7	26.4	30.8	24.5	
<b>Subject taught, grades 9–12</b>							†			
Math/science	28.3	5,169	39.4	26.9	40.5	25.8	20.3	20.3	19.2	
English language arts/social studies	26.7	5,903	39.1	24.3	36.5	21.1	20.8	21.3	18.1	
<b>General education/special education</b>										
General education	23.6	48,779	31.0	20.4	30.6	21.1	19.0	21.4	19.6	
Special education	25.7	10,059	35.3	20.8	30.8	24.3	20.8	25.1	20.8	
<b>Grade level taught</b>	†		†	†	†	†	†	†	†	
Elementary grades (kindergarten–5)	21.8	34,193	27.0	18.0	27.0	20.2	18.6	21.4	19.5	
Middle school grades (6–8)	28.5	19,825	33.3	25.0	34.3	27.5	24.3	28.8	24.5	
High school grades (9–12)	27.8	16,539	42.2	23.7	37.9	23.5	20.2	20.5	18.8	

Teacher characteristic	Overall									
	Percent leaving	Sample size <sup>a</sup>	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	
<b>Teacher attendance</b>	†		†	†	†	†	†	†	†	†
Regular (95 percent attendance or more)	18.9	35,426	26.5	15.4	26.4	15.9	13.6	16.3	14.8	
Frequently absent (75–94 percent attendance)	29.0	20,596	38.7	25.3	34.4	27.1	24.2	27.6	24.5	
Less than 75 percent attendance	51.7	2,794	58.1	50.5	55.2	49.4	51.8	48.9	46.1	
<b>Commute time</b>	†		†	†	†	†	†	†	†	†
Shorter than 15 minutes	18.6	15,037	24.5	14.8	21.1	18.8	16.3	17.8	16.5	
15–29 minutes	21.7	25,499	27.7	16.4	25.9	21.9	18.7	20.2	20.5	
30–59 minutes	22.9	13,042	28.4	18.1	26.8	22.6	21.0	22.7	20.5	
60 minutes or longer	36.7	968	48.6	23.6	35.9	36.2	33.6	35.0	37.7	

<sup>a</sup> Turnover rates differ by at least 5 percentage points between groups within the category.  
Note: The total number of teachers by grade level taught sums to more than the total sample size because teachers may teach at multiple grade levels. Teachers may also teach in multiple subject areas. The total sample size for each category may not sum to the overall sample size because some teachers are missing data for some characteristics and are excluded from the turnover calculation.  
a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district from 2010/11 through 2016/17).  
Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

**Table B9. Percentage of teachers leaving the School District of Philadelphia, by teacher characteristic and school year, 2010/11–2016/17**

Teacher characteristic	Overall									
	Percent leaving	Sample size <sup>a</sup>	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	
Overall	8.2	60,268	11.3	6.6	10.4	7.2	6.8	7.2	7.5	
<b>Years of teaching in the district</b>	†		†	†	†	†	†	†	†	†
Four or fewer years	11.0	15,372	14.9	8.5	9.2	9.7	9.8	10.8	11.2	
5–10 years	5.2	16,369	3.7	3.7	5.3	6.0	5.8	6.6	5.0	
11–17 years	4.4	14,501	4.4	3.2	5.8	4.7	4.0	4.4	4.1	
More than 17 years	13.1	12,595	18.8	10.3	23.6	9.4	9.8	8.5	9.2	
<b>Race/ethnicity</b>										
Black	7.8	15,002	9.5	5.9	10.8	7.8	6.3	7.1	6.6	
Hispanic	7.0	1,703	12.0	5.5	6.9	5.8	6.6	6.3	5.7	
White	8.4	40,078	11.6	6.8	10.6	7.0	7.0	7.1	7.6	
Other race/ethnicity	8.3	2,031	13.8	5.6	7.8	6.6	7.9	7.4	8.0	
<b>Gender</b>										
Female	8.1	43,468	10.7	6.3	10.6	7.5	6.8	6.9	7.2	
Male	8.4	15,370	12.2	6.9	9.9	6.1	6.7	7.9	7.8	
<b>Subject taught, grades 6–8</b>										
Math/science	7.7	5,724	7.5	6.8	10.2	7.1	8.0	7.3	6.9	
English language arts/social studies	7.8	6,006	7.9	5.8	9.7	5.9	7.9	10.2	7.8	

Teacher characteristic	Overall									
	Percent leaving	Sample size <sup>a</sup>	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	
<b>Subject taught, grades 9–12</b>										
Math/science	8.9	5,169	9.2	8.8	12.5	9.3	7.2	6.8	7.6	
English language arts/social studies	8.1	5,903	10.3	7.7	10.8	6.0	6.6	7.2	7.0	
<b>General education/special education</b>										
General education	7.9	48,779	11.1	6.3	9.7	6.8	6.6	6.9	7.2	
Special education	9.4	10,059	11.2	7.4	14.0	8.8	7.6	8.3	7.9	
<b>Grade level taught</b>										
Elementary grade (kindergarten–5)	7.5	34,193	10.0	5.7	9.7	7.1	6.4	6.5	7.0	
Middle school grade (6–8)	9.2	19,825	12.3	6.6	11.4	8.4	7.9	8.7	8.7	
High school grade (9–12)	9.4	16,539	13.9	8.0	11.8	7.6	7.0	7.5	7.7	
<b>Teacher attendance</b>										
Regular (95 percent attendance or more)	5.5	35,426	8.2	3.9	8.3	4.5	3.7	4.1	4.7	
Frequently absent (75–94 percent attendance)	10.6	20,596	14.9	8.7	11.9	9.4	9.0	9.9	9.9	
Less than 75 percent attendance	23.7	2,794	27.3	22.8	26.5	21.5	25.1	22.1	19.8	
<b>Commute time</b>										
Shorter than 15 minutes	7.1	15,037	9.8	6.2	8.6	6.4	5.9	6.1	6.3	
15–29 minutes	8.1	25,499	10.7	6.5	11.2	6.9	6.7	6.7	7.6	
30–59 minutes	8.3	13,042	10.6	5.8	10.6	7.7	7.6	8.1	7.4	
60 minutes or longer	15.4	968	21.6	9.8	9.9	16.9	12.5	20.0	14.6	

<sup>†</sup> Turnover rates differ by at least 5 percentage points between groups within the category.

Note: The total number of teachers by grade level taught sums to more than the total sample size because teachers may teach at multiple grade levels. Teachers may also teach in multiple subject areas. The total sample size for each category may not sum to the overall sample size because some teachers are missing data for some characteristics and are excluded from the turnover calculation.

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district from 2010/11 through 2016/17).

Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

**Table B10. Percentage of teachers leaving their school in the School District of Pennsylvania, by teacher evaluation rating and school year, 2014/15–2016/17**

Teacher evaluation rating	Overall					
	Percent leaving	Sample size <sup>a</sup>	2014/15	2015/16	2016/17	
Overall	21.2	24,215	20.3	22.9	20.3	
<b>Teacher effectiveness score</b>	†		†	†	†	
Failing or needs improvement (0–1.49) <sup>b</sup>	39.7	914	39.6	49.5	33.3	
Proficient (1.5–2.49)	17.1	18,564	15.8	20.7	15.0	
Distinguished (2.5–3)	11.0	2,629	7.2	12.7	9.5	
<b>Pennsylvania Value-Added Assessment System score</b>	†		†	†	†	
Failing or needs improvement (0–1.49)	23.5	745	27.4	42.9	14.9	
Proficient (1.5–2.49)	16.6	2,967	15.5	19.8	10.3	
Distinguished (2.5–3)	15.2	1,540	12.1	18.5	5.0	

† Turnover rates differ by at least 5 percentage points.

Note: The total sample size for each category does not sum to the overall sample size because some teachers are missing data for an evaluation rating and are excluded from the turnover calculation.

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district from 2014/15 through 2016/17).

b. The bottom two evaluation rating categories (failing and needs improvement) were combined because of small sample sizes in the failing category.

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Table B11. Percentage of teachers leaving the School District of Philadelphia, by teacher evaluation rating and school year, 2014/15–2016/17**

Teacher evaluation rating	Overall					
	Percent leaving	Sample size <sup>a</sup>	2014/15	2015/16	2016/17	
Overall	7.2	24,215	6.8	7.2	7.5	
<b>Teacher effectiveness score</b>	†		†	†	†	
Failing or needs improvement (0–1.49) <sup>b</sup>	12.0	914	9.7	14.4	12.9	
Proficient (1.5–2.49)	4.8	18,564	4.4	4.9	5.1	
Distinguished (2.5–3)	3.5	2,629	2.8	3.4	4.1	
<b>Pennsylvania Value-Added Assessment System score</b>			†			
Failing or needs improvement (0–1.49)	6.7	745	6.0	13.0	4.7	
Proficient (1.5–2.49)	3.9	2,967	3.9	3.8	4.0	
Distinguished (2.5–3)	3.9	1,540	3.2	4.4	3.1	

† Turnover rates differ by at least 5 percentage points.

Note: The total sample size for each category does not sum to the overall sample size because some teachers are missing data for an evaluation rating and are excluded from the turnover calculation.

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district from 2014/15 through 2016/17).

b. The bottom two evaluation rating categories (failing and needs improvement) were combined because of small sample sizes in the failing category.

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Teacher turnover by school characteristic and school year.** The main report describes differences in the schools that teachers left and schools where teachers stayed, highlighting school characteristics with a difference of at least 5 percentage points and a large relationship with teacher turnover based on the analyses for research question 3. This section presents the results by other school characteristics and by school year (table B12). This

section also presents the results of an analysis of differences between the schools where teachers who left the district taught and schools where teachers who stayed in the district taught (table B13).

**Table B12. Characteristics of the schools in which teachers taught in the School District of Philadelphia, by whether teachers left or stayed in their school and by school year, 2014/15–2016/17**

School characteristic	Overall		2014/15		2015/16		2016/17	
	Left school	Stayed in school	Sample size <sup>a</sup>	Left school	Stayed in school	Left school	Stayed in school	Left school
<b>Teacher survey construct score (percent positive responses)</b>								
School leadership	74.9	78.8	22,206	73.3	77.3	75.1	79.7	76.2
School climate	51.5	56.8 <sup>†</sup>	22,206	51.3	55.8	51.0	57.0 <sup>†</sup>	52.3
Teacher autonomy	88.0	89.2	22,206	88.0	89.2	88.5	89.6	87.4
Teacher respect	70.6	72.0	22,206	71.5	72.5	70.8	72.7	69.4
Student behavior	81.6	83.8	22,206	81.4	83.7	81.4	83.9	82.2
Collaboration	36.2	36.5	22,206	33.7	33.7	32.1	32.8	43.2
<b>School student characteristics (percent of students)</b>								
Advanced or proficient in math	15.9	22.9 <sup>†</sup>	23,976	15.6	22.0 <sup>†</sup>	16.0	24.4 <sup>†</sup>	16.2
Advanced or proficient in English language arts	28.9	36.5 <sup>†</sup>	23,976	28.6	35.8 <sup>†</sup>	28.9	37.6 <sup>†</sup>	29.2
Economically disadvantaged students	96.3	93.3	24,204	95.3	92.1	96.3	93.0	97.5
Black students	59.3	50.4 <sup>†</sup>	24,205	59.5	51.4 <sup>†</sup>	58.0	50.2 <sup>†</sup>	60.4
Hispanic students	20.1	20.0	24,199	20.2	19.6	20.6	19.9	19.6
White students	9.5	14.2	24,199	9.7	14.2	9.9	13.8	8.9
<b>Principal leadership</b>								
Years principal led the school	2.9	3.2	24,205	2.7	2.9	2.7	3.1	3.2
3.5								

<sup>†</sup> Characteristics of schools that teachers left are at least 5 percentage points different from characteristics of schools where teachers remained.

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district from 2014/15 through 2016/17).

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Table B13. Characteristics of the schools in which teachers taught, by whether teachers left or stayed in the School District of Philadelphia and by school year, 2014/15–2016/17**

School characteristic	Overall		2014/15		2015/16		2016/17	
	Left district	Stayed in district	Sample size <sup>a</sup>	Left district	Stayed in district	Left district	Stayed in district	Left district
<b>Teacher survey construct score (percent positive responses)</b>								
School leadership	76.2	78.1	22,206	74.9	76.6	76.8	78.8	76.8
School climate	53.5	55.8	22,206	52.9	55.0	53.7	55.8	53.8
Teacher autonomy	88.5	89.0	22,206	88.2	89.0	89.3	89.4	87.9
Teacher respect	71.0	71.8	22,206	71.7	72.4	71.8	72.3	69.8
Student behavior	82.6	83.4	22,206	82.4	83.2	82.6	83.4	82.6
Collaboration	36.8	36.4	22,206	33.9	33.6	32.9	32.6	43.1
<b>School student characteristics (percent of students)</b>								
Advanced or proficient in math	19.0	21.6	23,976	18.7	20.8	19.4	22.7	18.7
Advanced or proficient in English language arts	32.2	35.1	23,976	31.8	34.5	32.8	35.8	32.0
Economically disadvantaged students	95.2	93.9	24,204	93.3	92.7	95.6	93.6	96.4
Black students	57.0	51.9 <sup>†</sup>	24,205	56.5	52.8	55.9	51.7	58.4
Hispanic students	19.1	20.1	24,199	18.8	19.8	19.6	20.1	18.7
White students	11.2	13.3	24,199	12.3	13.3	10.9	13.1	10.6
<b>School leadership</b>								
Years principal led the school	2.9	3.1	24,205	2.6	2.9	2.8	3.0	3.3

<sup>†</sup> Characteristics of the schools that teachers left are at least 5 percentage points different from characteristics of the schools where teachers remained.

a. The number of teacher-years in the analysis (teachers multiplied by years employed in the district from 2014/15 through 2016/17).

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

### **Research question 3: How does teaching experience relate to whether teachers leave their school or leave the district?**

In addition to examining annual teacher turnover rates, the study team calculated the rate at which teachers left their school or left the district for each year of teaching in their school or in the district and the cumulative probability that teachers would leave their school or leave the district over time. The main report provides figures showing the percentage of teachers leaving for each year of teaching and the cumulative probability that teachers would leave their school or district. Table B14 summarizes the percentage of teachers leaving and the cumulative probability for each of the first 5 years of teaching and every 5 years between 5 and 30 years of teaching.

**Table B14. Teacher turnover in the School District of Philadelphia, by years of teaching in their school or district, 2010/11–2016/17**

Years of teaching	By years teaching in their school		By years teaching in the district	
	Percentage leaving their school	Cumulative probability of leaving their school	Percentage leaving the district	Cumulative probability of leaving the district
1	46	38	17	15
2	33	56	15	28
3	24	65	11	35
4	22	72	7	40
5	20	77	10	45
10	14	90	4	59
15	14	96	4	67
20	12	98	6	75
25	19	99	11	84
30	23	100	17	92

Note: The percent leaving and cumulative probability are not identical in year 1 because the percent leaving averages the percent of teachers who left across the three time points observed in year 1 (September, October, and April) while the cumulative probability summarizes the likelihood teachers would leave by the end of their first year.

Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

### ***Research question 3a: What other teacher and school characteristics are related to teachers leaving their school or leaving the district?***

In addition to looking at differences in teacher turnover separately by teacher and school characteristics, the study team examined how teacher and school characteristics influenced teacher turnover, after other characteristics were taken into account. The study team examined which teacher and school characteristics were related to teachers leaving their school and teachers leaving the district. Appendix A describes the methods used for each analysis. Only teachers with complete data across all years were included in the hazards models, which limited the sample to school years 2014/15 through 2016/17.

The main report discusses the teacher and school characteristics with the largest relationship to the likelihood of teachers leaving their school. Tables B15 and B16 provide detailed results for these characteristics, as well as results for additional teacher and school characteristics and results from the model of characteristics related to a teacher's likelihood of leaving the district. Table B17 provides results from an alternative model of teachers leaving the district that included time-dependent effects.

***Results of the hazards model analysis of teachers leaving their school and leaving the district.*** The coefficient for each variable in table B15 describes the effect of a one-unit difference in that variable on the log of the probability of teachers leaving their school or leaving the district. Coefficients from a Cox proportional hazards model can be difficult to interpret; therefore, table B15 also shows the hazard ratio and its confidence interval. The hazard ratio is the antilog of the coefficient ( $e^{(\text{coefficient})}$ ) and describes the effect of a one-unit difference in each variable on the probability of a teacher leaving. For example, the hazard ratio for retirement eligibility tells us that teachers who are eligible for retirement are 370 percent more likely to leave the district than teachers who are not eligible for retirement (calculated as the hazard ratio multiplied by 100). In contrast, teachers who are vested in the pension system (teachers who have worked enough years to qualify for retirement benefits) are 97 percent less likely to leave their district than teachers who are not vested (calculated by subtracting 1 from the hazard ratio and

multiplying by 100). The hazard ratio is expressed in terms of the percentage change in a teacher's probability of leaving.

Interpreting the influence of a characteristic on teacher turnover using hazard ratios when a one-unit change is very small can be difficult. For example, commute time is measured in minutes. A one-minute increase in commute time increases a teacher's probability of leaving the district by 1 percent. It might be more useful, though, to know the effect of a 10-minute increase in commute time, which can be calculated with the formula  $e^{(\text{coefficient} * \text{unit change})}$ . For this example, a 10-minute increase in commute time increases a teacher's probability of leaving the district by 7.7 percent ( $e^{(0.007 * 10)}$ ).

Table B16 presents the change in teachers' likelihood of leaving their school or the district with different magnitude changes in each characteristic that does not represent a teacher subgroup. Subgroups are excluded because a one-unit change represents belonging to that subgroup and therefore the hazard ratio provided in table B15 describes the effect of belonging to the group on teacher turnover.

**Table B15. Coefficients and hazard ratios from discrete time hazards model of teachers leaving their school and leaving the School District of Philadelphia, 2014/15–2016/17**

Variable	Leaving their school			Leaving the district		
	Coefficient (standard error)	Hazard ratio	95% confidence interval	Coefficient (standard error)	Hazard ratio	95% confidence interval
<b>Teacher characteristic</b>						
Eligible for retirement	0.555** (0.065)	1.74	(1.53, 1.98)	1.308** (0.097)	3.70	(3.05, 4.48)
Vested in pension system	-0.417** (0.055)	0.66	(0.59, 0.73)	-3.561** (0.423)	0.03	(0.01, 0.07)
Number of previous school moves	0.095** (0.021)	1.10	(1.05, 1.15)	na	na	na
Female	-0.036 (0.041)	0.96	(0.89, 1.05)	-0.049 (0.078)	0.95	(0.82, 1.11)
Black	0.262** (0.100)	1.30	(1.07, 1.58)	0.275 (0.171)	1.32	(0.94, 1.84)
Special education teacher	-0.086 (0.048)	0.92	(0.83, 1.01)	-0.102 (0.088)	0.90	(0.76, 1.07)
Frequently absent	0.401** (0.037)	1.49	(1.39, 1.60)	0.652** (0.069)	1.92	(1.68, 2.20)
Less than 75 percent attendance	0.758** (0.065)	2.13	(1.88, 2.42)	1.057** (0.119)	2.88	(2.28, 3.63)
Teacher effectiveness score	-0.699** (0.049)	0.50	(0.45, 0.55)	-0.674** (0.094)	0.51	(0.42, 0.61)
Commute time between home and school	0.005** (0.001)	1.00	(1.00, 1.01)	0.007** (0.002)	1.01	(1.00, 1.01)

Variable	Leaving their school			Leaving the district		
	Coefficient (standard error)	Hazard ratio	95% confidence interval	Coefficient (standard error)	Hazard ratio	95% confidence interval
<b>School characteristic</b>						
Grades 6–8	0.161** (0.041)	1.18	(1.08, 1.27)	0.054 (0.076)	1.05	(0.91, 1.22)
Grades 9–12	−0.070 (0.060)	0.93	(0.83, 1.05)	−0.133 (0.105)	0.88	(0.71, 1.08)
Percent of Black students (among non-Black teachers)	0.003** (0.001)	1.00	(1.00, 1.00)	0.004* (0.001)	1.00	(1.00, 1.01)
Percent of Black students (among Black teachers)	−0.004** (0.001)	1.00	(0.99, 1.00)	−0.008** (0.003)	0.99	(0.99, 1.00)
Percent of students scoring proficient or advanced in math	−0.004* (0.002)	1.00	(0.99, 1.00)	0.000 (0.003)	1.00	(0.99, 1.01)
Years principal led the school	−0.021** (0.007)	0.98	(0.97, 0.99)	−0.017 (0.013)	0.98	(0.96, 1.01)
Student–teacher ratio	0.007* (0.003)	1.01	(1.00, 1.01)	0.019** (0.005)	1.02	(1.01, 1.03)
<b>Teacher survey construct</b>						
School leadership	−0.003* (0.002)	1.00	(0.99, 1.00)	−0.006* (0.003)	0.99	(0.99, 1.00)
School climate	−0.016** (0.003)	0.98	(0.98, 0.99)	−0.003 (0.005)	1.00	(0.99, 1.01)
Teacher autonomy	−0.003 (0.004)	1.00	(0.99, 1.00)	0.002 (0.007)	1.00	(0.99, 1.02)
Teacher respect	0.005 (0.004)	1.00	(1.00, 1.01)	0.010 (0.009)	1.01	(0.99, 1.03)
Student behavior	0.002 (0.004)	1.00	(0.99, 1.01)	0.006 (0.008)	1.01	(0.99, 1.02)
Collaboration	−0.001 (0.002)	1.00	(1.00, 1.00)	0.000 (0.003)	1.00	(0.99, 1.01)
<b>Number of teacher observations</b>	<b>48,052</b>			<b>50,147</b>		

\* Significant at  $p < .05$ ; \*\* significant at  $p < .01$ .

na is not applicable (not included in the model).

Source: Authors' analysis of data from the School District of Philadelphia for 2010/11–2016/17.

**Table B16. Marginal effects of changes in teacher and school characteristics on teachers' probability of leaving their school or the School District of Philadelphia, 2014/15–2016/17 (percentage change)**

Teacher or school characteristic	Effect on leaving their school	Effect on leaving the district
<b>Number of previous school moves</b>		
One prior move	+9.9	na
Two prior moves	+20.9	na
<b>Teacher effectiveness score</b>		
1/3-point increase	-20.6	-19.9
1/2-point increase	-29.5	-28.6
<b>Commute time between home and school</b>		
10-minute increase	+5.5	+7.7
20-minute increase	+11.3	+15.9
<b>Percent of Black students (among non-Black teachers)</b>		
10 percentage point increase	+3.0	+3.8
20 percentage point increase	+6.1	+7.7
<b>Percentage of Black students (among Black teachers)</b>		
10 percentage point increase	-1.4	-4.3
20 percentage point increase	-2.8	-8.5
<b>Percent of students scoring proficient or advanced in math</b>		
10 percentage point increase	-4.0	-0.1
20 percentage point increase	-7.9	-0.2
<b>Years principal led the school</b>		
Two-year increase	-4.1	-3.3
Three-year increase	-6.1	-4.9
<b>Student-teacher ratio</b>		
5-student increase	+3.5	+9.8
10-student increase	+7.1	+20.5
<b>School leadership (survey construct)</b>		
10 percentage point increase in positive responses	-3.3	-6.0
20 percentage point increase in positive responses	-6.5	-11.7
<b>School climate (survey construct)</b>		
10 percentage point increase in positive responses	-14.7	-2.5
20 percentage point increase in positive responses	-27.2	-5.0
<b>Teacher autonomy (survey construct)</b>		
10 percentage point increase in positive responses	-2.5	+1.6
20 percentage point increase in positive responses	-4.9	+3.3
<b>Teacher respect (survey construct)</b>		
10 percentage point increase in positive responses	+4.8	+10.4
20 percentage point increase in positive responses	+9.9	+21.8

Teacher or school characteristic	Effect on leaving their school	Effect on leaving the district
<b>Student behavior (survey construct)</b>		
10 percentage point increase in positive responses	+2.4	+6.7
20 percentage point increase in positive responses	+4.8	+13.9
<b>Collaboration (survey construct)</b>		
10 percentage point increase in positive responses	-0.6	+0.5
20 percentage point increase in positive responses	-1.3	+1.0
na is not applicable (not included in the model).		
Source: Authors' analysis of data from the School District of Philadelphia.		

*Results from the hazards model analysis of teachers leaving the district with time-dependent effects.* For each hazards model described above (the model of teachers leaving their school and the model of teachers leaving the district), the study team tested the proportional hazards assumption. As described in appendix A, the proportional hazards assumption assumes that the change in risk with each covariate is constant over time. This assumption might be violated if, for example, a variable increases a teacher's risk of leaving in the first five years of teaching but has no effect on turnover later in a teacher's tenure.

For the model of teachers leaving the district, one variable, retirement eligibility, violated the proportional hazards assumption, meaning that its influence on teachers' likelihood of leaving changed over time. This is to be expected since teachers typically become eligible for retirement near the end of their career; retirement eligibility would thus have no effect early in a teacher's career but would have a potentially large effect in later years. To adjust for this, the study team estimated a model interacting retirement eligibility with time. Table B17 presents the results for this model. Results for the model with time-dependent effects are similar to results of the model without time-dependent effects. The same characteristics are significantly related to the likelihood of teachers leaving the district in both models. Coefficients in both models did not differ for 8 of the characteristics and were similar for the remaining 13 characteristics.

For teacher characteristics other than retirement eligibility, the results in table B17 can be interpreted in the same way as the results in table B15. The results for retirement eligibility can be interpreted as follows: In their first year of teaching in the district, teachers who are eligible for retirement are 10 times more likely to leave than teachers who are not eligible for retirement. The effect of retirement eligibility then decreases by 5 percent for each subsequent year.

Because very few teachers would be eligible for retirement in their first year employed in the district, it makes more sense to look at the effect of retirement at 30 years, when most teachers are eligible to retire. At 30 years of employment in the district, teachers who are eligible for retirement are two times as likely to leave as teachers who are not eligible for retirement.<sup>2</sup> This is less than the 3.7 times higher risk of leaving reported for teachers eligible for retirement in the model without time-dependent effects. This difference is due to differences in how the change in risk is calculated in each model. The model without time-dependent effects presents the average increase in risk across the length of a teacher's career in the district rather than the increase at one time point (such as 30 years).

<sup>2</sup> This is calculated as  $10.61 * (e^{* \ln(0.95)} * 30)$ .

**Table B17. Coefficients and hazard ratios from discrete time hazards model of teachers leaving the School District of Philadelphia, with time-dependent effects, 2014/15–2016/17**

Variable	Coefficient (standard error)	Hazard ratio	95% confidence interval
<b>Teacher characteristic</b>			
Vested in pension system	-3.652** (0.419)	0.03	(0.01, 0.06)
Female	-0.043 (0.077)	0.96	(0.82, 1.11)
Black	0.257 (0.125)	1.29	(0.93, 1.80)
Special education teacher	-0.126 (0.088)	0.88	(0.74, 1.05)
Frequently absent	0.658** (0.069)	1.93	(1.69, 2.21)
Less than 75 percent attendance	1.057** (0.119)	2.88	(2.28, 3.63)
Teacher effectiveness score	-0.667** (0.093)	0.51	(0.43, 0.62)
Commute time between home and school	0.008** (0.002)	1.01	(1.00, 1.01)
<b>School characteristic</b>			
Grades 6–8	0.060 (0.076)	1.06	(0.92, 1.23)
Grades 9–12	-0.131 (0.104)	0.88	(0.72, 1.08)
Percent of Black students (among non-Black teachers)	0.003* (0.001)	1.00	(1.00, 1.01)
Percent of Black students (among Black teachers)	-0.008** (0.003)	0.99	(0.99, 1.00)
Percent of students scoring proficient or advanced in math	0.000 (0.003)	1.00	(0.99, 1.01)
Years principal led the school	-0.017 (0.013)	0.98	(0.96, 1.01)
Student–teacher ratio	0.019** (0.005)	1.02	(1.01, 1.03)

Variable	Coefficient (standard error)	Hazard ratio	95% confidence interval
<b>Teacher survey construct</b>			
School leadership	−0.006 (0.003)	0.99	(0.99, 1.00)
School climate	−0.002 (0.005)	1.00	(0.99, 1.01)
Teacher autonomy	0.002 (0.007)	1.00	(0.99, 1.02)
Teacher respect	0.009 (0.009)	1.01	(0.99, 1.03)
Student behavior	0.006 (0.008)	1.01	(0.99, 1.02)
Collaboration	0.001 (0.003)	1.00	(0.99, 1.01)
<b>Eligible for retirement: time-dependent effects</b>			
First year	2.362** (0.209)	10.61	(7.05, 15.99)
Change in effect with each year	−0.548** (0.010)	0.95	(0.93, 0.97)
<b>Number of teacher observations</b>	<b>50,147</b>		

\* Significant at  $p < .05$ ; \*\* significant at  $p < .01$ .

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

### ***Research question 3b: Does the relationship between teacher and school characteristics and turnover differ between effective teachers and ineffective teachers?***

Table B18 presents results for the analysis of whether the relationship between teacher and school characteristics and teacher turnover differed between teachers rated proficient or distinguished (effective teachers) and teachers rated failing or needs improvement (ineffective teachers). Tables B18 and B19 compare findings for the two groups of teachers on all variables identified under research question 3a as substantively related to turnover and policy relevant. One characteristic, school climate, had a significantly different relationship with turnover for teachers rated proficient or distinguished than for teachers rated failing or needs improvement. In addition to being statistically significant, school climate had a substantively different relationship with turnover depending on teachers' ratings. As described in the main report, a 10 percentage point increase in positive responses to school climate survey questions was related to a 5 percent increase in the likelihood that teachers rated failing or needs improvement would leave their school. However, for teachers rated proficient or distinguished, a 10 percentage point increase in positive responses to school climate survey questions was related to a 18 percent decrease in the likelihood of leaving their school (for example, from 20 percent to 16 percent). Table B19 presents the change in teachers' likelihood of leaving their school for each group of teachers with different magnitude changes in characteristics other than teacher subgroups.

**Table B18. Coefficients and hazard ratios for interactions between teachers' evaluation ratings and other teacher and school characteristics for model of teachers leaving their school in the School District of Philadelphia, 2014/15–2016/17**

Variable	Teachers leaving their school		
	Coefficient (standard error)	Hazard ratio	95% confidence interval
<b>Number of previous school moves</b>			
Teachers rated failing or needs improvement	0.046 (0.039)	1.05	(0.97, 1.13)
Teachers rated proficient or distinguished	0.058 (0.042)	1.06	(0.98, 1.15)
<b>Identifying as Black</b>			
Teachers rated failing or needs improvement	-0.023 (0.314)	0.98	(0.53, 1.81)
Teachers rated proficient or distinguished	0.269 (0.335)	1.31	(0.68, 2.52)
<b>Frequently absent</b>			
Teachers rated failing or needs improvement	0.303 (0.124)	1.35	(1.06, 1.73)
Teachers rated proficient or distinguished	0.126 (0.131)	1.13	(0.88, 1.47)
<b>Grades 6–8</b>			
Teachers rated failing or needs improvement	0.028 (0.141)	1.03	(0.78, 1.36)
Teachers rated proficient or distinguished	0.154 (0.149)	1.17	(0.87, 1.56)
<b>School climate (survey construct)</b>			
Teachers rated failing or needs improvement	0.005 (0.009)	1.00	(0.99, 1.02)
Teachers rated proficient or distinguished	-0.025* (0.009)	0.98	(0.96, 0.99)

\* Differences between groups are significant at  $p < .05$ .

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.

**Table B19. Marginal effects of changes in teacher and school characteristics on teachers' probability of leaving their school in the School District of Philadelphia for interactions between teachers' evaluation ratings and other teacher and school characteristics, 2014/15–2016/17 (percentage change)**

Teacher and school characteristic	Teachers rated failing or needs improvement	Teachers rated proficient or distinguished
<b>Number of previous school moves</b>		
One prior move	+4.7	+11.0
Two prior moves	+9.7	+23.3
<b>School climate (survey construct)</b>		
10 percentage point increase in positive responses	+5.0	-17.9
20 percentage point increase in positive responses	+10.2	-32.6

Source: Authors' analysis of data from the School District of Philadelphia for 2014/15–2016/17.